GENU PECTIN

C. F. T. R. I.

CFTRI-MYSORE
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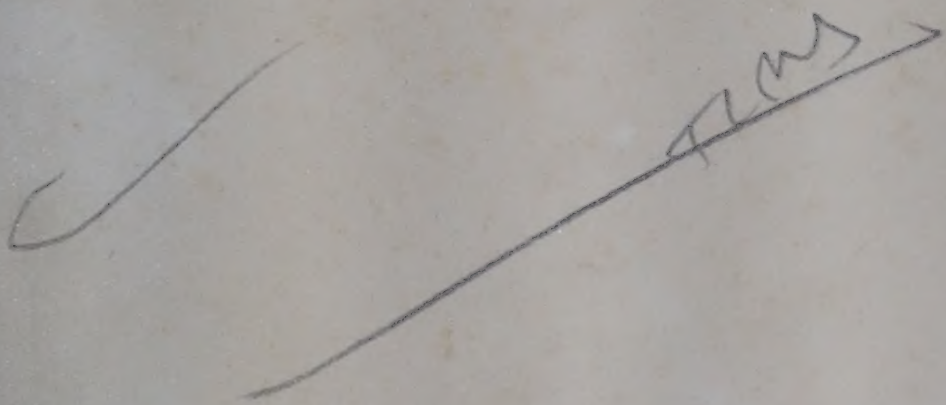
(4) cooking formulas
(5) invert sugar
(6) Consistency
(7) pH
(8) soluble solids

(9) fruit products
(10) jams
(11) jellies



GENU PECTIN

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HANDBOOK

for

MARMALADE, JAM AND JELLY MANUFACTURERS

KØBENHAVNS PEKTINFABRIK
COPENHAGEN, DENMARK

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PREFACE

When preparing the directions for the use of our GENU Pectin, we have tried to present our information in a way, enabling factories working with as well as without laboratory control to arrange the manufacturing processes where Pectin is employed accordingly.

In the introduction we shall briefly outline the Nomenclature of Pectin, as well as we shall refer to Gel Structure and Pectic Enzymes.

Our customers will possibly find these references superfluous, but as necessarily our research work is not limited to Pectin manufacture only, but also comprises the manufacturing processes where Pectin is used we have nevertheless decided to include these sections as the research laboratories of other factories might deal with the same problems.

We have stated no actual directions for the cooking of marmalades, jams and jellies, as this processing is highly depending on the plant and equipment of each individual factory, but on page 61. "Questions and Answers" some of the problems arising during the practical processing have been dealt with. If further information should be desired, we earnestly solicit your inquiries and we shall be only too pleased to give you the best possible answer.

Our GENU Pectin is introduced in factories all over the world. Many of our customers live far from Denmark and will maybe never visit our country. We therefore avail ourselves of the opportunity on the next pages to introduce Denmark in a few glimpses.

September 19[illegible]

Cyclists are typical for Denmark as you will note from this picture of the Town Hall Square in Copenhagen.

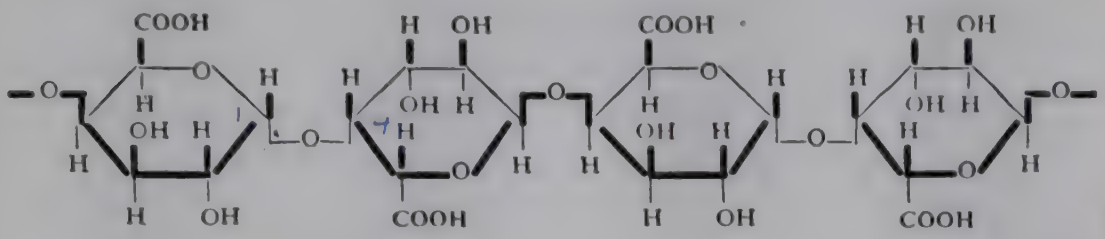
The Royal Hunting Lodge in the Deer Park, a popular resort just 20 minutes' drive outside the City of Copenhagen.

Frederiksborg Castle in North Zealand about 20 miles from Copenhagen. Built in renaissance style in the period 1600—1620 by the Danish King Christian the IV. Now used as museum for famous national, historical collections.

Denmark is a country of islands. You need not go very far, if you want a swim. There are a lot of lovely sea-side resorts — here is one.

PECTIN

Pectin is generic term for various polygalacturonic acids, which, however, only differ very little. A polygalacturonic acid is shown below:



Nomenclature.

Pectic acid is polygalacturonic acid. The salts of pectic acid are called Pectates. Pectinic Acid is polygalacturonic acid, of which 10%—40% of the carboxyl groups is esterified with methyl alcohol, and salts of this acid are called Pectinates. Pectin is polygalacturonic acid, of which 40%—100% of the carboxyl groups is esterified with methyl alcohol. The name of Pectin is, however, very often used for all the above groups. Protopectin is the pectic substance in fruits, which cannot be directly extracted with water. Pectase is an enzyme, able of de-esterifying the pectin. Pectinase is an enzyme, capable of splitting the polygalacturonic acid chain.

Occurrence.

Pectic substances are more or less present in all fruits and plants. However, the amount of pectic substance and its composition vary very much from one kind to another. Ample pectin occurs in citrus fruits, apples, black currants, sugar beets, tomatoes, gooseberries, and red currants. For industrial manufacture so far only apples, citrus fruits and sugar beets are used.

Pectin Properties

The most important property of pectic substances, is their ability to form a gel, that is under certain conditions—above all by addition of sugar and acid—to form a firm elastic gel. Already small amounts of pectin—2-5 per mille—are able to bind

big quantities of sugar and water. This ability is utilized in the manufacture of jams and jellies from fruit, for example apple jelly and red currant jelly, as these are frequently containing pectin in sufficient quantities to form a gel by addition of sugar and acid. However, many fruits, for example raspberry and strawberry, are so deficient in pectin, or contain pectin of such a poor quality that gel formation is only possible by adding additional pectin. It is therefore of the greatest importance that pectin with fixed jellifying abilities can be manufactured, making a complete control of the gel properties of the finished product possible.

Gel and Gel Formation.

For many years the definition of a gel has been discussed, however, it has not yet been possible to establish a well defined and exactly limited defenition of a gel. Still today thick pastes, plastic substances and similar substances are called gels. In the following is by a pectin gel meant a system consisting of more than 95% solid liquid (sugar and water), and which is able to maintain its form and possessing a certain elasticity. It is obvious that one of the conditions of a gel forming pectin being able to immobilize a considerable amount of solid liquid (sugar and water) is that the gel forming particles are dispersed in the liquid in a way that a three-dimensional network is formed. This is easiest accomplished when the gel forming particle is a high-polymeric compound, and especially easy when this highpolymeric compound is an anisodiametric macro-molecule, such as a linear molecule. The gel forming molecule is not moving freely in the jelly, but the component molecules adhere. In the following we only deal with pectin as the gel forming substance, and the term PECTIN means here polygalacturonic acid with at least 50% of the carboxyl groups being esterified with methyl alcohol.

The Structure of Highmethoxyl Pectin Gels.

Pectin gels belong to the so-called secondary valence gels. The formation process and the basis for this formation of secondary valence gels is very complicated, depending on many various factors. In order to understand pectin gel formation

and the basis for same, it is necessary to go into the details of the physical-chemical properties of pectin. The pectin molecule is linear and has a molecular weight (commercial pectins 100 Grade—300 Grade) of 25.000—150.000, i. e. a single pectin molecule contains 125—750 units. Pectin behaves approximately as a monobasic carboxylic acid, never being 100 per cent esterified. Consequently pectin may be titrated as a monobasic acid with for example 1/10 n. sodium hydroxide solution. The neutralization point of pectin is about p_H 7.5. Hence the percentage of esterifying or the acid equivalent weight of the pectin may be found, i. e. the amount of carboxyl groups which is esterified or, the pectin weight in grams containing one mol-carboxyl. The equivalent weight of pectin varies from 500—2000, for example is the equivalent weight of citrus pectin (rapid set) about 800, whereas the equivalent weight of apple pectin (rapid set) is 1000—1500. Accordingly pectin is a carboxylic acid, and the carboxyl group as such in aqueous solution dissociates more or less in hydroxonium ions and carboxyl ions as follows:

$$COOH + H_2O \rightleftharpoons COO^- + H_3O^+$$

This dissociation conveys to the macro-molecule itself a negative charge, and the bigger the dissociation (which means the higher the p_H of the aqueous solution), the bigger the charge. Consequently the pectin molecules repel each other. In other words one of the conditions of the formation of aqueous pectin gels is that this dissociation is being reduced as much as possible, that is the negative charge of the pectin molecule must be reduced to a minimum. This may be obtained by adding a stronger acid than pectin, bringing the p_H nearer to or below the p_H conveyed to the aqueous solution by the pectin only (p_H about 3.2) An essential but insufficient condition for the formation of aqueous pectin gels is consequently that the p_H of the solution is 3.2 or less.

It is well known that pectin is excessively hydrated in an aqueous solution, and the consequence is that even a non-dissociated pectin does not precipitate in aqueous solution. It is therefore essential to use a dehydrating agent, and various

compounds may be applied. Compounds containing highly hydrofile groups such as hydroxyl groups are very suitable. It is also well known that pectin gels containing alcohol, glycerine and sugars can be made. Common for all three groups is that they are highly hydrofile substances and consequently able to dehydrate the pectin molecules. Of these substances only sugars are of any interest in this case. Some researchmen are attributing another function by gel formation to sugar, being of the opinion that hydrogen bonds are formed between the hydroxyl groups of the sugar and those of the pectin, stabilizing the gel structure.

As mentioned pectin gels belong to the big group of gels called secondary valence gels. The linking of the macro-molecules is effected by the various secondary bonds (hydrogen bonds and possibly sugar bonds). These secondary bonds are of course the weak points of the gel, for example will an increase of the temperature generally be sufficient to loosen these bonds, i. e. the gels are termoreversible and also frequently displaying an unlimited swelling in excess of solid liquid, generally causing the gel to turn liquid by the strong dilution. A great number of the secondary valence gels show distinct hysteresis, i. e. that a gel setting at for example 60° C. only melts again at, let us say, 110° C. This is the case with the pectin gels, a circumstance qualifying that they are extensively used for confectionery, where the jellies when baked are exposed to high temperatures.

In a pectin-sugar-acid solution there are two forces important to understand the gel formation: 1) the associating force originating from the tendency to form secondary bonds, and 2) the loosening force—the Browning movements. A basis for strong gel formation is of course that the pectin molecules have a certain mobility, enabling them to arrange themselves with the maximum chance of the greatest amount of secondary bonds. This is the reason why too rapid a cooling of a warm pectin-sugar-acid solution must not take place, as the molecules are not allowed time enough to find their best position in the network. The same applies in case of the so-called post-setting. A gel cooled too rapidly has a very long post-setting

time, the molecules having practically no mobility in the partly jellified cold mass. A pectin-sugar-acid solution with for example p_H 4.0 does not set, even when stored for years. If a strong acid is added to this solution, adjusting p_H to less than 3.0, an association of the pectin molecules takes place. The solution has the quickest setting time at 50° C. Below this temperature the setting time is increased owing to the slow movement of the pectin molecules. The basis for maximum breaking strength is of course that the setting takes place without any interruption. It is important to note that vibrations of the foundation where the setting takes place, originating for example from machines or motors, may completely destroy the gel formation.

The Influence of various Factors on the Breaking Strength of Pectin-Sugar Gels.

In the following is dealt with pectin gels with sugar and acid, constructed as a network. This network is built up by the linear pectin macro-molecules, the construction of which must accordingly be of great importance to the gel structure. Pectins of different origin possess very different properties, especially with regard to the amount of pectin required to form a certain standard gel.

These properties are mainly the following four:

1) Length of pectin molecules as well as the polydispersity of pectin.
2) Percentage of esterification.
3) Ballast substances.
4) Acid and electrolytes.

Re 1)

The length of the chain molecules is of course of the greatest importance to the formation of a steady big-sized network. The grade value of the pectin is therefore first of all depending on the molecular weight of the pectin. A minimum amount of gel forming substances is of course always essential for gel

formation. The function expressing the relation between the breaking strength of different gels made with the same pectin, and the pectin concentration, is the same applying to other gel forming substances, for example gelatine, and looks as follows:

$$\text{The logarithm of the breaking strength} = a \times \text{log. pectin concentration} + b$$

where a and b are constants. This is the very function used by us at the construction of the nomograms fig. 2 and 3.

Furthermore the pectin grades have proved to pass off parallel to the grade of polymerisation of the pectin, that is to the average molecular weight of the pectin, owing to the fact that a commercial pectin always consists of molecules with different molecular weights. As the length of linear macro-molecules is determining the viscosity of an aqueous solution, the grade value of the pectin may be determined by measuring the viscosity of an aqueous solution, provided this viscosity is measured under exactly fixed conditions.

From the above it appears that a decrease of the molecular weight of a given pectin will result in a strong decrease of the grade value. This decrease of the molecular weight may be due to

a) Acids.
b) Bases.
c) Enzyme pectinase.
d) Deterioration by oxide.
e) Deterioration by heat.

Re a) The stability of the pectin molecule length against acid is directly depending on the p_H of the solution. At about p_H 3.0 the molecules have their greatest stability. It decreases at lower p_H, but only becomes perceptible at p_H less than 0.5, on the basis that the temperature is kept at about 20° C. At higher temperatures the stability decreases rapidly, being for example at 70° C. very poor with a p_H less than 1.5 in the solution.

Re b) The stability of the pectin molecule in an aqueous solution against bases is very poor, even at 20° C. For instance will a pectin solution with an average molecular weight of 100.000 at 20° C. and p_H 11 deteriorate so much in an hour that the molecular weight is only 20.000. This instability against base is of course still more distinct at higher temperatures.

Re c) Most fruits containing pectin also contain slight amounts of the enzyme Pectinase, which splits up the molecules of the pectin. This is indicated by the fact that generally raw pulp, i. e. pulp not being exposed to thermal treatment, which in the beginning contains some pectin grades, does not contribute at all to the gel formation after long storage, in other words does not contain any pectin of sufficiently high molecular weight. Most fungis contain considerable—generally even very big—amounts of enzymes, and to benefit from the natural pectin content of the pulp, it is therefore essential to prevent even the slightest formation of mould, as well as it is of course necessary to be on guard against any fungis residue in the containers, used for the storage of the pulp. The pectin enzyme may be destroyed in a few minutes by steaming, i. e. at temperatures at about 80°—85° C.

Re d) It has been proved that the pectin molecule may be split by oxidation processes. For instance is ascorbic acid (Vitamin C) able to split the molecules in the pectin with assistance of certain metal ions, such as ferri-ions. However, this splitting of the molecules requires the access of oxygen. The oxide deterioration of the pectin molecules may be observed in pulps, which have for some reason or other been iron contaminated. The oxidation process can be prevented, if the pulp contains highly reducing substances, as for instance HSO_3^- ions.

Re e) The stability of the pectin molecule is strongly decreased by increasing temperature. Above 70° C. this is especially perceptible. It is therefore essential to limit the cooking of jams as much as possible, as well as it is essential to cool down the

jams to 85°—90° C. before filling in containers (in case of containers larger than 2—3 kilos), as otherwise the pectin will be destroyed during the slow cooling. In addition this cooling obviously prevents the inversion of the sugar to advance too much.

Re 2)

As far as known the degree of esterification of the pectin does not matter very much to its jellifying ability, but is has great influence on the setting time. Several fruits contain small amounts of the enzyme Pectase, which is able of de-esterifying the pectin (for instance citrus fruits), and in order to benefit from the pectin content of the fruit itself, the pulps of these fruits must be exposed to thermal treatment. The pectin may also be slowly de-esterified by acid, hence the pectin in long stored sour pulps (orange bitter) has been converted into low-methoxyl pectin or maybe pectic acid, indicated by the pulp being very viscous or even almost completely jellified. From pulps of this kind it is practically impossible to make jam, as the lowmethoxyl pectin prevents the proper setting of the commercial pectin added.

Re 3)

Pectin always contains various amounts of carbohydrates, such as Arabanes and Galaktanes. These substances have presumably no influence on the jellifying ability of the pectin, but must rather be considered being mixed and not chemically combined with it. The pectin may, however, according to manufacturing process and raw material, contain certain groups combined to the pectin with primary bonds, and for steric reasons these groups will of course change the grade value of the pectin. It has for instance been proved that the pectin of certain fruits contains acetylated hydroxyl groups, and this is probably the reason why many fruits and plants, containing large amounts of pectin of great molecular weight, nevertheless do not form a gel by addition of sugar and acid.

Re 4)

As mentioned previously the addition of acid (the decrease of the p_H of the solution) has great influence on the jellifying ability of the pectin, as acid is forcing back the dissociation of the pectin carboxyl groups, thereby increasing the associating tendency of the molecules. Thus a given pectin has a p_H optimum by which the greatest gel breaking strength is attained. This optimum is in practise in the p_H range of 2.9—3.4, so that outside this range a breaking strength less than the maximum one is obtained. The decrease of the breaking strength in case of lower p_H is due to the setting temperature being strongly increased by the shifting of p_H towards 2, resulting in a pre-setting before the filling. However, an exact p_H optimum for a given pectin cannot be stated without simultaneously stating the sugar concentration used. By increasing sugar concentration the p_H optimum is shifted to higher p_H. For instance may a gel with 70%—75% sugar be made with a p_H as high as 3.3—3.4. Certain salts have like other electrolytes influence on the setting time. Sodium salts of weak acids can for example prolong the setting time (E. g. sodium citrate and sodium acetate).

MANUFACTURE OF JAMS, MARMALADES AND JELLIES

IN the manufacture of any product there are two important points to be observed, in order to secure that the best results are obtained by the manufacturer:

that goods of the highest quality are produced

at prices allowing a margin of profit.

This can only be attained by exercising a strict control of the manufacturing process by drawing samples of the raw materials as well as of the finished products, subjecting these not only to taste and sight tests, but in every case, whenever possible, to a laboratory operating analysis.

In a marmalade-, jam- and jelly-production, the finished product should be tested for

Flavour, Colour, Soluble Solids, p_H, Consistency, Invert Sugar.

When in the following reference is made to jam only, this is to simplify the text. The same rules apply of course to marmalade and jellies as well.

With regard to flavour and colour, judgment must necessarily be "a matter of taste", whilst standard samples may be applied for comparison. (The colour, however, is subject to change during storage.)

DETERMINATION OF SOLUBLE SOLIDS

The simplest, quickest and most accurate method for the determination of the soluble solids content in jam is by means of a Sugar Refractometer.

This refractometer reads in per cent sugar and consequently indicates directly the soluble solids content in the jam, provided

the latter has been cooled down to 20° C., or to 28° C. provided a Tropic Refractometer is used for determination.

DETERMINATION OF p_H VALUE

The p_H value in fruit and jam is determined by a p_H Meter with glass electrode and measured in a cooled portion of the jam without any water dilution. If for instance the jam has been diluted with distilled water ratio 1 to 1, the p_H values stated in Table 1 will rise with 0.1—0.2 units.

TABLE 1

Correct p_H Value in Jam corresponding to various Soluble Solids
Based on non-diluted Jam

Per Cent Soluble Solids in Finished Product	p_H Value
68—72%	3.1—3.3
65—68%	3.0—3.2
60—65%	2.8—3.0

CONSISTENCY

The general test for determining whether the firmness of marmalades, jams and jellies is satisfactory is probably the finger test. This test is highly subjective, but it must be admitted that experts having obtained great experience through many years' practise with this testing are decidedly able to estimate even slight differences in the texture. But as stated, it requires many years of experience for an expert who handles the problem every day, and a production control in the laboratory, to be made by people who do not require the expert's many years of practical experience, is desired by many factories.

The old fashioned cooking method, by which a proper consistency is reached by simply evaporating fruit and sugar until a suitable viscous mass is obtained, has long since been abandoned by every up-to-date factory. To get the right consistency either the pectin contained in the fruit is used, or pectin is added to the extent necessary to obtain the firmness desired.

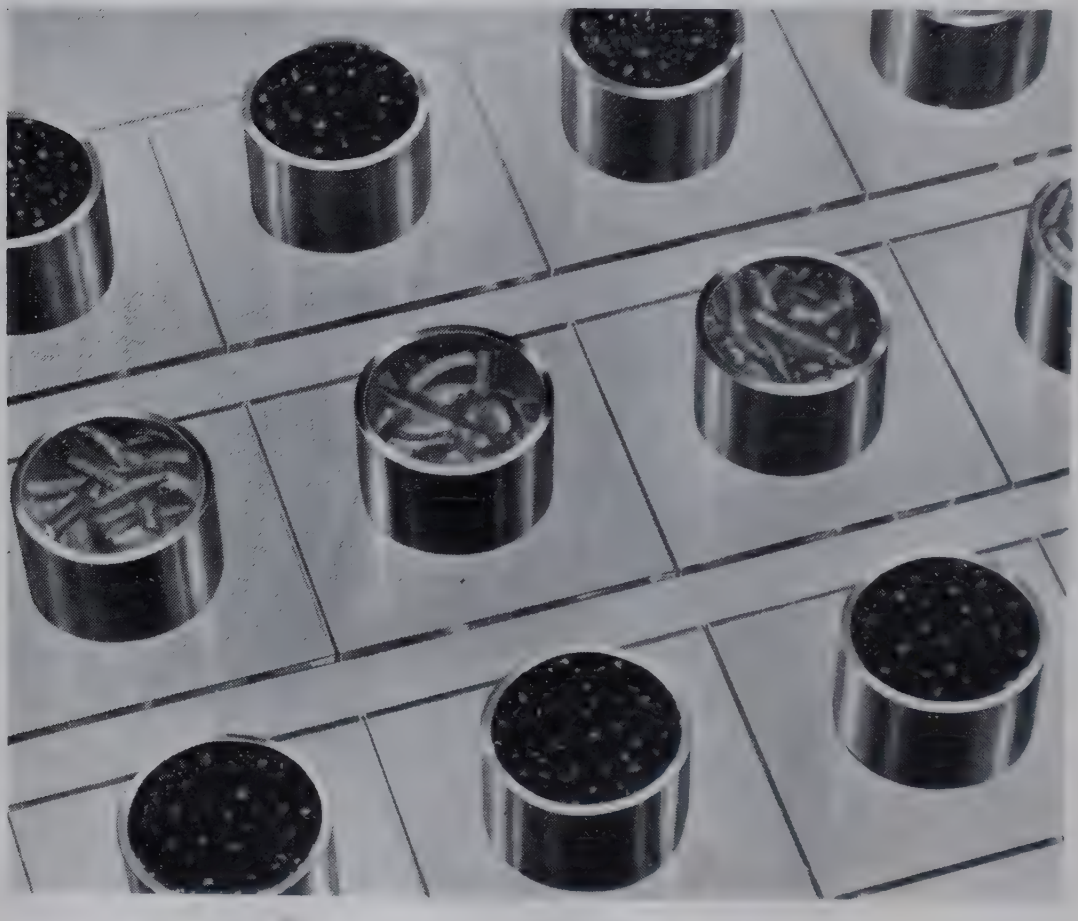
At KØBENHAVNS PEKTINFABRIK GENU Pectin is continually tested by a Gelometer, both during the production process and as a finished product. As it is exclusively the pectin that gives the desired jellification in marmalades, jams and jellies, nothing is more natural than testing the effect of the pectin on the finished product in the same way.

When testing pectin we are measuring the breaking strength of the test jelly, and when experts are finger testing the firmness of jam, it is also the breaking strength that is measured. The analysis which we recommend for the control of the firmness of jam is therefore that adopted by the experts in practise, but now carried out in the laboratory.

The same gelometer as used for testing pectin may be applied, and with regard to the use we refer to *Method for Determination of Pectin Grade by Modified Tarr-Baker Gelometer.* (See pages 69 to 87 incl.) The employment of the gelometer must be strictly in accordance with the directions given, and we shall here mention only the drawing of samples for testing.

HOW TO DRAW SAMPLES FOR CONTROL OF CONSISTENCY

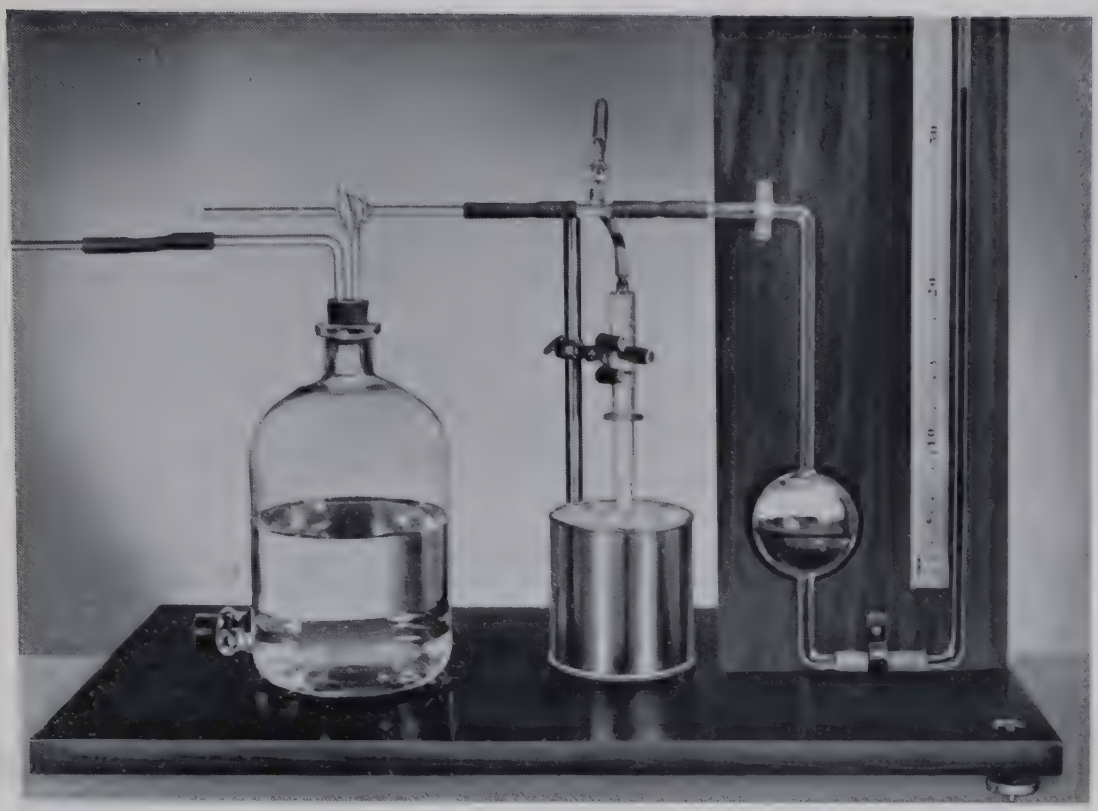
Through wrong cooling of jams and jellies the jellifying ability of the pectin may be partly destroyed, and we therefore recommend that at the production control in the jam- and jelly-manufacture samples are drawn in jelly rings, as mentioned in the analysis method (pages 76—79 incl.) immediately after the cooking operation is finished *(acid added)*.



These samples must be allowed to stand perfectly still for 24 hours, and must be tested as indicated in the same method.

The next test is a check analysis of the packed finished product with a set jel after at least 24-hours storage. Samples of the finished product are simply taken as follows:

If the jam or jelly is packed in tins, cut open the bottom of the tin in the usual way and place the tin under the piston of

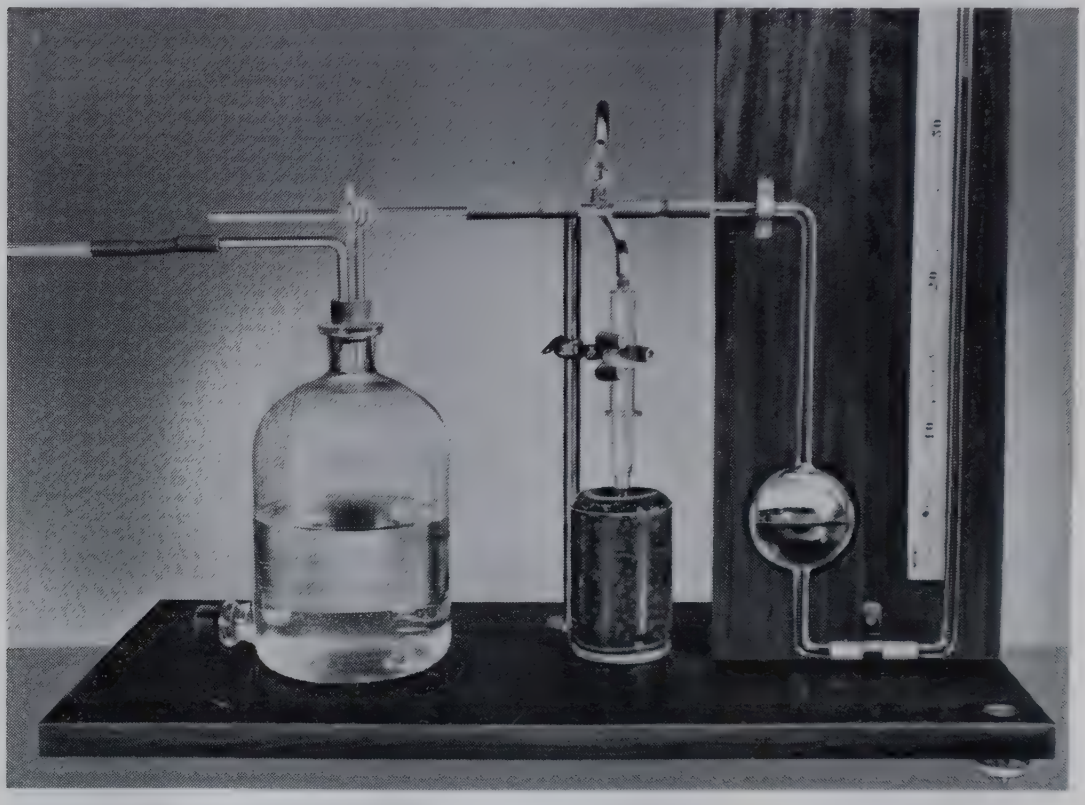


the gelometer. Then measure the breaking strength in the normal way, as indicated in the analysis method. (See pages 69 to 87 incl.)

(Explanation of above photo see next page.)

If the jam is packed in jars, the testing may be made in various ways, but we will take it that the easiest way is approximately 1 cm from the bottom of the jar to cut a slot with a glazier's diamond.

Turn the jar bottom up and place a thick woollen thread moistened in alcohol approximately 1 cm under the slot. Set the thread on fire, and the bottom will usually separate after the first kindling. Possibly the bottom must be dipped in cold water after the heating of the jar. Does the bottom not separate after the first kindling the process must be repeated.



Then place the jar—like the tin—under the piston of the gelometer and carry out the test.

The testing of the first sample, drawn immediately after the cooking operation is finished (acid added), gives a figure for the firmness obtained in the manufacture, and by a daily comparison of the figures a standard is reached for the firmness wanted. This figure is not only of importance for the control of the daily production, but as shown later in the section of *Formulas* (pages 37 to 39 and 44 to 51 incl.), it provides the basis for the amount of pectin to be used.

By comparison of control sample Number 1 and control sample Number 2, the latter drawn from the finished product, it can be established to what extent cooling and emptying have spoilt the setting. It is, however, up to individual choice as to whether a firm jam is wanted, or if simply the pectin is added to give a heavy viscosity. The latter is obtained for example by rolling the tins on a conveyor belt through water cooling. If a firm jam is desired, the packages must be allowed to stand perfectly still for not less than 24 hours.

INVERT SUGAR — SUGAR CHRYSTALLIZATION — SYNERESIS (WEEPING)

In order to prevent chrystallization of the sugar in jams and jellies, it is necessary that part of the sugar be converted into invert sugar or to apply glucose. The former takes place during the cooking operation, but it is of the utmost importance to exercise a strict control with the invert sugar content, as too much of same is one of the causes of syneresis (weeping).

Table 2 indicates the limits for invert sugar at various soluble solids in the jam. As even at a temperature of 20° C. the invert sugar content increases by storage, it should always be kept at the lowest possible allowance.

TABLE 2

Limits for Invert Sugar Content in Jam

Per Cent Refractometer Soluble Solids	Invert Sugar
65	0—44
66	2—42
67	6—40
68	11—39
69	15—37
70	20—35
71	24—34
72	29—33

TABLE 3

The Influence of the Boiling Time on the Inversion of Sucrose in a Jam with Soluble Solids Content 65% and p_H 3.0

Boiling Time in Minutes	Per Cent Invert Sugar
1	2.5
2	5.0
3	7.3
4	9.4
5	11.6
6	13.6
8	17.4
10	21.3
15	29.6
20	36.5
30	44.9

TABLE 4

The Inversion of Sucrose at various Temperatures in a Jam with Soluble Solids Content 65% and p_H 3.0

Temperature in Centigrades	10 Min.	20 Min.	30 Min.	60 Min.
100	13.8	24.6	33.1	49.4
90	5.7	9.5	15.6	26.8
80	2.2	4.3	6.2	11.7
70	0.7	1.4	2.1	4.2
60	—	—	0.7	1.4
50	—	—	—	0.5

Conclusion

In order to avoid too big a content of invert sugar it must be recommended to boil the jam as shortly as possible, and to make certain that no further increase of the invert sugar takes place after the boiling do not leave the jam in the cooking kettle longer than strictly necessary. Furthermore it must be strongly recommended to keep a strictly constant time table for the boiling and for the emptying of cooking kettles, as a constant invert sugar content is of the greatest importance to the manufacture of a uniform jam.

TITRIMETRIC DETERMINATION OF INVERT SUGAR IN JAM NOT CONTAINING GLUCOSE

The following method is quick and suitable as operating analysis, where absolutely accurate figures are not required:

Reagents.

Fehling Solution A — 69.28 g $CuSO_4,5H_2O$ dissolved in 1 liter of distilled water.

Fehling Solution B — 346 g Sodium Potassium Tartrate ($KNaC_4H_4O_6,4H_2O$) and 130 g Sodium Hydroxyd dissolved in 1 liter of distilled water.

Keep the two solutions separated until use.

Determination.

Weigh 50 g of cooled jam into a beaker and add 100 ml of distilled H_2O. Stir the mixture until the jam is evenly dispersed. Add distilled water to a total weight of 250 g and boil for about 1 minute, then cool immediately to 15° C. Transfer the content to a 250 ml measuring flask and fill distilled water up to the mark. Then filter this solution into a 250 ml Erlenmeyer flask. Pipette 10 ml of the filtrate into a 100 ml measuring flask and add distilled water up to the mark.

Now pipette 25 ml Fehling Solution { 25 ml Fehling Solution A / 25 ml Fehling Solution B

into a 250 ml Erlenmeyer flask, which is placed on a tripod, fitted with asbestos wire netting and Bunsen burner. Fill a burette with the filtered jam solution.

Then add 10 ml of the jam solution to the Fehling Solution and heat to boiling. Whilst boiling add slowly the jam solution from the burette, until the Fehling Solution assumes a red colour. The end point may be improved by adding three drops of Methylene Blue Solution. The consumption in ml of the 2 per cent jam solution is now read off the burette, and per cent invert sugar in the original jam is indicated in the following table.

TABLE 5

2 Per Cent Jam Solution in ml.	Per Cent Invert Sugar in original Jam
15	40.80
16	38.30
17	36.00
18	34.00
19	32.30
20	30.70
21	29.25
22	27.90
23	26.70
24	25.60
25	24.60
26	23.70
27	22.80
28	21.90
29	21.20
30	20.50
31	19.90
32	19.20
33	18.70
34	18.10
35	17.60
36	17.10
37	16.70
38	16.20
39	15.80
40	15.40
41	15.00
42	14.70
43	14.30
44	14.00
45	13.70
46	13.40
47	13.10
48	12.90
49	12.60
50	12.30

TITRIMETRIC DETERMINATION OF INVERT SUGAR IN JAM CONTAINING GLUCOSE, WHEN THE SUCROSE PERCENTAGE IS KNOWN

1. A determination of total reducing sugar is made excactly as described on page 29, the result being calculated as invert sugar.
2. Then a determination of the total reducing sugar is made after having inverted the sucrose present as follows:

Weigh 50 g of jam into a 400 ml beaker and add about 170 ml of distilled water. Disperse the jam completely and heat the solution to 90° C. Add now 10 ml of concentrated HCl, keep the temperature at 90° C. for five minutes, and cool to 20° C. Neutralise the solution with a 50% NaOH solution and transfer into a 250 ml measuring flask. Then fill up to the mark with distilled water. Filter the solution and pipette 25 ml of the clear filtrate into a 500 ml measuring flask. Then fill up to the mark with distilled water. From the 1 per cent jam solution thus made, the reducing sugar is determined as described previously. Table 5 is applied for the calculation, and the figure arrived at multiplied by two on account of the double dilution.

Computing the Result.

Per cent reducing sugar according to determination Number 1 calculated as invert sugar = a

Per cent reducing sugar according to determination Number 2 calculated as invert sugar = b

(b — a) × 0.95 indicates the balance of sucrose in the jam, and by subtracting this figure from the figure indicating the known amount of sucrose originally added, the amount of invert sugar is obtained.

POLARIMETRIC DETERMINATION OF INVERT SUGAR IN JAM NOT CONTAINING GLUCOSE

Reagents.

1. Concentrated Ammonium Hydroxide
2. 20% Lead Acetate Solution
3. Saturated Solution of $Na_2HPO_4,2H_2O$ in distilled water.

Directions.

Determine the soluble solids in the jam by a refractometer. Weigh 100 g of jam into a 400 ml beaker and stir it thoroughly with 50 ml of distilled water. Add more water bringing the weight up to 250 g and neutralise with NH_3 water. Heat the solution to boiling point and cool again immediately. Transfer the contents of the beaker into a 250 ml measuring flask and fill up to the mark with distilled water. Add to this jam solution about 2 g of "Filter Aid" and filter the solution through a Büchner funnel. Pipette 50 ml of the solution into a 100 ml measuring flask and add water up to 80 ml. While shaking add 10 ml of Lead Acetate Solution, then 5 ml of the Sodium Phosphate Solution. Finally fill up with distilled water.

The solution is centrifuged, and the rotatory power of the clear solution is determined by means of a Polarimeter in 200 mm Tube (Sodium Light).

Computing the Result.

a = per cent soluble solids in jam

d = rotatory power

Per cent invert sugar in jam = $0.767 \times a - d \times 2.866$.

POLARIMETRIC DETERMINATION OF INVERT SUGAR IN JAM CONTAINING GLUCOSE, WHEN THE SUCROSE PERCENTAGE IS KNOWN

Reagents.

1. Concentrated Hydrochlorid Acid (Sp. Gr. 1.19)
2. 20% Lead Acetate Solution
3. Saturated Solution of $Na_2HPO_4,2H_2O$ in distilled water
4. Concentrated Ammonium Hydroxide.

Directions.

1. Weigh 100 g of jam into a 400 ml beaker and stir it thoroughly into 50 ml of distilled water. Add more water to a total weight of 250 g and neutralise with NH_3 water. Heat the solution to boiling point and cool again immediately. Transfer the content into a 250 ml measuring flask and add distilled water up to 250 ml. Add 2 g of "Filter Aid" and filter the solution through a Büchner funnel. Pipette 50 ml of the filtered solution into a 100 ml measuring flask and add distilled water up to 80 ml. Then add 10 ml of Lead Acetate Solution while shaking, and finally 5 ml of Sodium Phosphate Solution and water up to 100 ml.

The solution is centrifuged, and the rotatory power of the clear solution is determined by a Polarimeter in 200 mm Tube, (Sodium Light). Rotatory power = (d_1).

2. Weigh 100 g of the same jam into a 400 ml beaker and stir it thoroughly into 50 ml of distilled water. Add more water up to a total weight of about 210 g and heat the solution to 90° C. Add 10 ml of concentrated HCl, keep the temperature at 90° C. for five minutes, then cool. After cooling neutralise with concentrated NH_3 water, transfer the solution to a 250 ml measuring flask and fill up with distilled water. The further procedure is as described on page 32. Rotatory power = (d_2).

Computing the Result

Per cent invert sugar in jam = $p - 2.884 \times (d_1 - d_2)$, where p = per cent granulated sugar added to the finished product + sugar originating from the pulp, and easily found from the formula

and the determination of the refractometer soluble solids content in the finished product.

Example.

Formula	Refractometer Soluble Solids	Soluble Solids in Kilos
45 kilos Granulated Sugar	100	45
20 „ Glucose 80%	80	16
35 „ Pulp	10	3.5
300 g Pectin	100	0.3
200 g Citric Acid	100	0.2
		65.0

Refractometer soluble solids in finished product was for example 66.8,

$$\text{that is, } p = \frac{48.5 \times 66.8}{65} = 49.84$$

(48.5 = 45 kilos of granulated sugar + 3.5 kilos of invert sugar originating from the pulp).

DETERMINATION OF THE PECTIN CONTENT IN FRESH FRUIT AND PULP

On account of the control of raw materials being purchased and the subsequent composition of the manufacturing formulas for jams and jellies, it is of importance to determine the pectin content in fresh fruit and fruit pulp.

For this purpose the gelometer may also be employed as follows:

Weigh 200 g of fruit pulp into a 400 g beaker. If the pulp contains large firm pieces of fruit, take care to have same disintegrated.

Carefully eliminate preservatives such as sulphur dioxide by boiling and add water, until the weight being again 200 g. Cool the pulp and measure p_H. If the p_H in the pulp is not within the range 2.8 — 3.0 add concentrated hydrochloric acid, trinatrium phosphate or sodium citrate, until the p_H is adjusted within this range. The per cent soluble solids is found by the

refractometer. The further procedure now depends on the amount of pectin contained in the pulp. From apple-, black currant-, red currant- and gooseberry-pulp test jellies may generally be made without addition of any pectin to that present. However, in the case of orange-, apricot-, raspberry-, strawberry- and other pulps, it will mostly be necessary to use additional pectin when preparing test jellies, but this is best illustrated by the following examples.

Example 1.
Determination of the Jelly Grade in Fruit or Pulp with large Pectin Content

Refractometer soluble solids 11% and p_H adjusted to 2.8—3.0. Weigh 60 g of cooked fruit or pulp into a 400 ml beaker (with spatula) that has been tared on a balance. Add 25 ml of KP Buffer. (See page 81.) Weigh into a second beaker granulated sugar as follows:

$$125 - \frac{60 \text{ (weight of pulp)} \times 11 \text{ (soluble solids in pulp)}}{100} = 118.4 \text{ g.}$$

Heat pulp and buffer to boiling. Add $^1/_3$ of the granulated sugar and heat again to boiling point. Now add another $^1/_3$ of the granulated sugar and continue heating. Add the remainder of the sugar and boil for 10—20 seconds. Adjust the weight of the contents of the beaker to 200 g and fill five jelly rings, exactly as described in *Method for Determination of Pectin Grade.* (See pages 77—79 incl.) After the five rings have been allowed to stand quiet for three hours the breaking strength is measured on the gelometer, as illustrated in the same method and the grade value appears from Nomogram fig. 3.

Example 2.
Determination of the Jelly Grade in Fruit or Pulp deficient in Pectin.

Refractometer soluble solids, let us say, 8.8% and p_H adjusted to 2.8—3.0. The pulp contains insufficient quantities

of pectin to form a sufficiently firm jelly for testing the breaking strength without additional pectin. In order to carry out this test a powdered pectin with an exactly known grade value must be at disposal. For this purpose GENU Pectin Type A 200 Grade can immediately be applied, as the grade value is always uniform. The determination of the jelly grade will then be as follows: Weigh off

$$125 - \frac{60 \text{ (weight of pulp)} \times 8.8 \text{ (soluble solids in pulp)}}{100} = 119.7 \text{ g}$$

of granulated sugar. Weigh then on a watch glass 0.400 g of GENU Pectin Type A 200 Grade by an analytical balance. Remove with a camel hair brush this amount of pectin into a tared 400 ml glass (with spatula). Add about 10 g of the quantity of sugar and carefully mix it with the pectin. Weigh 60 g of the pulp into the same beaker, and add 25 ml of KP Buffer. Place the beaker on an asbestos wire netting and heat to boiling while carefully stirring. Add the remainder of the sugar in 3—4 portions as described above and finally boil for 10—20 seconds. Adjust the weight of the content to 200 g and fill five jelly rings. Now measure the strength on the gelometer after three hours. Then an average breaking strength of for example 550 mm water pressure is found. The calculation of the grade value of the pulp is now made as follows:

The Nomogram fig. 3 indicates that the 60 g of pulp + 0.4 g of pectin have a total grade value of 2.12 Grade. The grade value of the pulp has consequently been

$$\frac{60 \times 2.12 - 0.4 \times 200}{60} = 0.79 \sim 0.8$$

(60 = pulp, 2.12 = total grade value according to Nomogram fig. 3, 0.4 = weight of pectin, 200 = grade value of pectin).

In the analysis method is stated that when pectin is tested with fruit juices (and consequently also with pulps), no buffer solution is necessary, and according to the above it is nevertheless recommended to use buffer salts. Acid only may certain-

ly be used, but in order to obtain the correct result, the p_H must be adjusted to exactly 3.0, and this necessitates the cooking of several batches, until the correct p_H is found. By the addition of buffer salts this inconvenience is obviated, as the p_H is adjusted automotically at 3.0.

HOW TO MAKE COOKING FORMULAS

It may appear remarkable that we only now arrive at the point that ought to be the starting point in a manufacturing process, that is the composition of cooking formulas, but we have purposely started with the check analyses of the finished product, in order to obtain through them a standard for the firmness desired. This standard is the very basis for the composition of formulas, as the amount of pectin to be added depends on the firmness wanted.

The following formulas for jams have partly been composed on the basis of the previously mentioned check analyses of the jams, and partly been composed in such a manner that factories which do neither undertake these check analyses nor determine the pectin content in the fresh fruit or the pulp to be employed, can look up the amount of pectin required. The formulas are classified partly into 3 groups based on the quantity of fruit or pulp wanted in the jam, and partly into four groups depending on the pectin content of the fruit.

When making a formula it is necessary in the first place to decide upon the soluble solids, and in the second place the percentage of fruit or fruit pulp to be contained in the finished product. Having decided these two factors, the amount of pectin and the amount of acid must be fixed.

How much Pectin must be present in Jam to obtain the Breaking Strength desired?

In order to be able to calculate the pectin content—partly in form of pectin in the quantity of fruit used, and partly in form of additional pectin—the following table gives the required amount of jelly units in a jam, when the breaking strength has been measured on the gelometer:

TABLE 6

Gelometer Breaking Strength and corresponding Jelly Units in Jam

mm Water Pressure	Jelly Units per loo Parts Finished Product
100	31.5
200	42.5
300	50.0
400	56.5
500	61.5
600	67.5
700	71.0
800	76.0
900	80.0
1000	84.0
1200	91.0
1400	96.0
1600	100.0
1800	104.0

The definition of jelly units is best explained by an example:

When 100 kilos of jam must contain 100 jelly units, and the fruit used does not contain pectin with jellifying ability, 1 kilo of pectin 100 Grade must be used—or if using a 200 Grade pectin:

$$\frac{100}{200} = 0.500 \text{ kilos.}$$

Should 65 jelly units be wanted in 100 kilos of jam (again provided that the fruit used does not

contain pectin with jellifying ability), and a 200 Grade pectin is used, the amount of pectin is calculated as follows:

$$\frac{65}{200} = 0.325 \text{ kilos}$$

The jelly units indicated in Table 6 are based on jams with 65% soluble solids content.

If the soluble solids content in the finished product is to be less than 65% it will be necessary to use more pectin in order to obtain the firmness desired, and if the soluble solids is to be greater less pectin must be calculated for.

TABLE 7

Correction Table for Pectin Amounts required for Jams with Soluble Solids other than 65%

Per Cent Soluble Solids in Finished Product	Per Cent Pectin (of Pectin Amounts required at 65% Soluble Solids)
70	85
69	87
68	90
67	93
66	96
65	100
64	104
63	108
62	113
61	119
60	127

TABLE 8

Pectin Equivalents based on Jelly Grade

Quantities stated in Grams

One Kilo of Grade below is equal in Jel Strength } to	100 Grade	105 Grade	150 Grade	160 Grade	200 Grade	240 Grade	250 Grade	300 Grade	320 Grade
100 Grade	1000	952	667	625	500	417	400	333	312
105 „	1050	1000	700	656	525	437	421	350	328
150 „	1500	1423	1000	939	750	625	600	500	468
160 „	1600	1524	1067	1000	800	667	640	533	500
200 „	2000	1905	1333	1250	1000	833	800	667	625
240 „	2400	2285	1600	1500	1200	1000	960	800	750
250 „	2500	2381	1667	1562	1225	1042	1000	833	781
300 „	3000	2857	2000	1875	1500	1250	1200	1000	938
320 „	3200	3050	2133	2000	1600	1333	1280	1067	1000

Computing the Amount of Pectin to be added, when the Grade Value of the Pulp is known:

The breaking strength of the jam is measured to 600 mm water pressure corresponding to 65 jelly units. The pectin content of the pulp or the fresh fruit is measured to 0.4 Grade.

40 kilos of fruit per 100 kilos of jam are to be employed.
The jam must contain ..... 65 jelly units
From the pulp is obtained 40 × 0.4 ..... 16 „ „
To be added in form of powdered pectin 49 jelly units

If GENU Pectin Type A or D 200 Grade is used, $\frac{49}{200} =$ 0.245 kilos must be employed.

WHETHER TO USE SLOW SET OR RAPID SET GENU PECTIN?

As it appears from the following formulas for jam, we have stated the amount of pectin to be used as GENU Pectin Type A Rapid Set respectively GENU Pectin Type D Slow Set.

General rules for when to apply one or the other can as a matter of fact not be definitely given. It depends in the highest degree partly on the kind of jam to be produced, and partly on the factory equipment of each individual factory.

For certain processes, however, a Slow Set Pectin may be employed with advantage.

For the packaging of jam in paraffined cardboard, GENU Pectin Type D (Slow Set) may be advantageously employed. In order to prevent the melting of the paraffin wax it is generally necessary to cool the jam to 60°—70° C. before filling. GENU Pectin Type A (Rapid Set) cannot stand such cooling without the jellifying ability of the pectin being more or less destroyed. However, GENU Pectin Type D (Slow Set) can stand this cooling.

Is it desired to allow especially long time for the filling of the jam, either for the above reason, that the jam must be cooled, or for any other reason, we recommend the use of GENU Pectin Type D (Slow Set).

If whole fruit jam is made, or for example orange marmalade with slices, and an uniform suspension of the fruit pieces is wanted, it is essential that the jam already when being packed is suffiently viscous, and this can only be attained by using GENU Pectin Type A (Rapid Set).

However, there is nothing to prevent the use of a suitable mix of Rapid Set and Slow Set Pectin. When making, let us say, whole fruit strawberry jam, GENU Pectin Type A (Rapid Set) gives a suitable viscosity in the jam, so that the fruits do not rise to the surface, while GENU Pectin Type D (Slow Set) gives a suitable firm setting.

ACID

To establish the quantity of acid required two methods may be employed.

1. An estimated quantity of acid is added to a trial batch and p_H tested on the p_H Meter. Having not—with the first addition of acid—obtained the correct p_H add a little more, until the batch shows the correct p_H.
2. But it is easier if the amount of acid to be used for the batch, when a given acidity is wanted, can be determined theoretically.

Table 9 indicates the amount of acid necessary to reduce the p_H in 100 kilos of fruit by 0.1 unit. The following interchangeable Standard Acid Solutions are calculated for:

50% Tartaric Acid Solution or
50% Citric Acid Solution or
80% Lactic Acid Solution

TABLE 9

Mililiter Interchangeable Standard Acid Solutions required to reduce p_H in 100 Kilos of Fruit with 0.1 Unit

Fruits	p_H	50% Tartaric Acid	50% Citric Acid	80% Lactic Acid
Apple (Summer)	3.1—3.7	180	230	190
Apple (Winter)	3.0—3.4	180	350	200
Apricot	3.0—3.6	250	350	260
Bilberry	2.8—3.0	300	600	420
Blackberry	3.8—4.2	130	230	140
Carrot	4.2—4.6	40	120	40
Cherry	2.6—3.7	350	800	380
Cowberry	2.7—2.9	400	780	500
Damson	3.3—3.7	120	200	130
Elderberry	3.6—3.8	170	280	210
Gooseberry	2.8—3.3	470		
Grapefruit	2.8—3.2	500	1200	600
Melon	4.0—4.4	60	110	70
Morello	3.5—3.8			190
Mountain-Ash Berry	2.7—2.9	400	700	500
Mulberry	3.0—3.2		480	
Orange (Bitter)	2.9—3.2	650	1000	660
Orange (Sweet)	3.0—3.4	240	340	280
Pear	3.4—4.1	65	130	80
Plum	3.0—3.5	280	550	280
Pumpkin	4.2—4.6	100	200	125
Raspberry	3.3—3.6	200	350	230
Red Currant	2.6—2.8			650
Rhubarb	2.0—2.9	700		
Strawberry	3.0—3.4	230	460	280
Tomato (Green)	3.9—4.2	120	250	140
Tomato (Red)	4.1—4.2	110	240	130

Example

In order to make e. g. 100 kilos of strawberry jam with a p_H of 3.1 and a fruit content of 58 kilos, the addition of acid should according to Table 9, when p_H in the strawberry pulp is 3.3, be 266 ml 50% Tartaric Acid Solution or 534 ml 50% Citric Acid Solution or 324 ml 80% Lactic Acid Solution.

The above figures are based on fresh fruit, or in case of pulp on the preserving acid such as sulphur dioxyde having been removed by cooking.

Furthermore the calculation of the requirements of acid only holds good provided a fine quality of sugar is used, which in itself has no acid requirements. When poor qualities of sugar are used, it is generally necessary to calculate with additional about 100 ml of 50% Citric Acid Solution (or a corresponding amount of the other acid solutions) per 50 kilos of sugar, in order to reduce the alkalinity of the sugar.

FORMULAS

The formulas for marmalades and jams are prepared on the assumption that fresh fully ripe fruits are used, and they may serve as a guide for the composition of the formulas of each individual factory.

According to the fruit content wanted in the jam, the formulas are divided into 3 main groups:

Quality I: 50% Fruit and 50% Sugar
„ II: 45% Fruit in Finished Product
„ III: 35% „ „ „ „

Within these 3 main groups formulas are given for jams, made from fruits with different pectin content. On the basis of the average pectin content in various fruits they may be classified as follows:

TABLE 10

Pectin Content in various Fruits

A	Apples (jams of this fruit are usually made without addition of pectin, hence no formula).
B	Gooseberries, Plums, Red Currants, Quinces, Black Currants.
C	Grapefruit, Blackberries, Strawberries, Raspberries, Pineapples.
D	Peaches, Pears, Damsons, Apricots.
E	Cherries, Bilberries.

In each formula five different amounts of pectin are indicated, corresponding to the pectin content to be used for various size packages.

TABLE 11

Amounts of Jelly Units required for the Containers stated in Formulas pages 46 to 51 inclusive

Packages	Measured to mm W. Press.	Corresponding Jelly Units
1) 1/2—1/1 kg jar	560	65
2) 2 1/2 „ container	790	75
3) 5 „ „	1020	85
4) 10 „ „	1220	92
5) 20 „ „	1700	102

4) and 5) are too firm for the housekeeping and principally intended for the firmness wanted by bakers and confectioners.

FORMULAS FOR JAMS

Quality I: 50 Per Cent Fruit and 50 Per Cent Sugar.

Gooseberry, Plum, Red Currant, Quince, Black Currant.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 58 kilos at abt **0.8** Grade	**46**			11	6.4
GENU Pectin A 200 Grade or D 200 Grade					
1) 100—125 g	20	**66**	600		
2) 150—175 „	30	**76**	800		
3) 200—225 „	40	**86**	1100	100	0.2
4) 225—250 „	45	**91**	1250		
5) 275—300 „	55	**101**	1700		
Sugar 58 kilos				100	58.0
50% Citric Acid Solution 200—350 ml ..				50	0.2
YIELD 100 kilos					64.8

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Grapefruit, Blackberry, Strawberry, Raspberry, Pineapple.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 58 kilos at abt. **0.5** Grade	**30**			10	5.8
GENU Pectin A 200 Grade or D 200 Grade					
1) 175—200 g	35	**65**	600		
2) 225—250 „	45	**75**	800		
3) 275—300 „	55	**85**	1100	100	0.3
4) 300—325 „	60	**90**	1200		
5) 350—375 „	70	**100**	1600		
Sugar 58 kilos				100	58.0
50% Citric Acid Solution 500 ml				50	0.3
YIELD 100 kilos					64.4

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Peach, Pear, Damson, Apricot.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 60 kilos					
at abt. **0.3** Grade	18			7	4.2
GENU Pectin					
A 200 Grade					
or D 200 Grade					
1) 225—250 g	45	63	550		
2) 275—300 „	55	73	750		
3) 325—350 „	65	83	1000	100	0.3
4) 375—400 „	75	93	1250		
5) 425—450 „	85	103	1800		
Sugar 60 kilos				100	60.0
50% Citric Acid So-					
lution 700 ml				50	0.4
YIELD 100 kilos					64.9

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Cherry, Bilberry.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 58 kilos					
at abt. **0** Grade	**0**			10	5.8
GENU Pectin					
A 200 Grade					
or D 200 Grade					
1) 300—325 g	60	60	500		
2) 350—375 „	70	70	700		
3) 400—425 „	80	80	950	100	0.4
4) 450—475 „	90	90	1200		
5) 500—525 „	100	100	1600		
Sugar 58 kilos				100	58.0
50% Citric Acid So-					
lution 800 ml				50	0.4
YIELD 100 kilos					64.6

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Quality II: 45 Per Cent Fruit in Finished Product.

Gooseberry, Plum, Red Currant, Quince, Black Currant.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 45 kilos at abt. **0.8** Grade	35			11	5.0
GENU Pectin A 200 Grade or D 200 Grade					
1) 150—175 g	30	65	600		
2) 200—225 „	40	75	800		
3) 250—275 „	50	85	1100	100	0.2
4) 275—300 „	55	90	1200		
5) 325—350 „	65	100	1600		
Sugar 60 kilos				100	60.0
50% Citric Acid Solution 200 ml				50	0.1
YIELD 100 kilos					65.3

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Grapefruit, Blackberry, Strawberry, Raspberry, Pineapple.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 45 kilos at abt. **0.5** Grade	23			9	4.0
GENU Pectin A 200 Grade or D 200 Grade					
1) 200—225 g	40	63	550		
2) 250—275 „	50	73	750		
3) 300—325 „	60	83	1000	100	0.3
4) 325—350 „	65	88	1200		
5) 375—400 „	75	98	1550		
Sugar 60 kilos				100	60.0
50% Citric Acid Solution 400 ml				50	0.2
YIELD 100 kilos					64.5

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Peach, Pear, Damson, Apricot.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 45 kilos					
at abt. **0.2** Grade	**10**			8	3.6
GENU Pectin					
A 200 Grade					
or D 200 Grade					
1) 275—300 g	55	65	600		
2) 325—350 „	65	75	800		
3) 375—400 „	75	85	1100	100	0.4
4) 425—450 „	85	95	1400		
5) 475—500 „	95	105	1800		
Sugar 60 kilos				100	60.0
50% Citric Acid So-					
lution 600 ml				50	0.3
YIELD 100 kilos					64.3

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Cherry, Bilberry.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 45 kilos					
at abt. **0** Grade	**0**			10	4.5
GENU Pectin					
A 200 Grade					
or D 200 Grade					
1) 300—325 g	60	60	500		
2) 350—375 „	70	70	700		
3) 400—425 „	80	80	950	100	0.4
4) 450—475 „	90	90	1200		
5) 500—525 „	100	100	1600		
Sugar 60 kilos				100	60.0
50% Citric Acid So-					
lution 700 ml				50	0.4
YIELD 100 kilos					65.3

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Quality III: 35 Per Cent Fruit in Finished Product.

Gooseberry, Plum, Red Currant, Quince, Black Currant.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 35 kilos at abt. 0.8 Grade	28			11	3.9
Water 10 kilos				0	0.0
GENU Pectin A 200 Grade or D 200 Grade					
1) 175—200 g	35	63	550		
2) 225—250 „	45	73	750		
3) 275—300 „	55	83	1000	100	0.3
4) 300—325 „	60	88	1200		
5) 350—375 „	70	98	1550		
Sugar 61 kilos				100	61.0
50% Citric Acid Solution 200 ml				50	0.1
YIELD 100 kilos					65.3

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Grapefruit, Blackberry, Strawberry, Raspberry, Pineapple.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 35 kilos at abt. 0.5 Grade	18			9	3.2
Water 10 kilos				0	0.0
GENU Pectin A 200 Grade or D 200 Grade					
1) 225—250 g	45	63	650		
2) 275—300 „	55	73	750		
3) 325—350 „	65	83	1000	100	0.2
4) 350—375 „	70	88	1200		
5) 400—450 „	80	98	1550		
Sugar 61 kilos				100	61.0
50% Citric Acid Solution 350 ml				50	0.2
YIELD 100 kilos					64.6

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Peach, Pear, Damson, Apricot.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 35 kilos					
at abt. **0.3** Grade	**10**			8	2.8
Water 10 kilos				0	0.0
GENU Pectin					
A 200 Grade					
or D 200 Grade					
1) 275—300 g	55	65	600		
2) 325—350 „	65	75	800		
3) 375—400 „	75	85	1100	100	0.4
4) 425—450 „	85	95	1400		
5) 475—500 „	95	105	1800		
Sugar 62 kilos				100	62.0
50% Citric Acid So-					
lution 400 ml				50	0.2
YIELD 100 kilos					65.4

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Cherry, Bilberry.

	Jelly Units	Total Jelly Units in Jam	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit 35 kilos					
at abt. **0** Grade	**0**			10	3.5
Water 10 kilos				0	0.0
GENU Pectin					
A 200 Grade					
or D 200 Grade					
1) 300—325 g	60	60	500		
2) 350—375 „	70	70	700		
3) 400—475 „	80	80	950	100	0.4
4) 450—475 „	90	90	1200		
5) 500—525 „	100	100	1600		
Sugar 61 kilos				100	61.0
50% Citric Acid So-					
lution 600 ml				50	0.3
YIELD 100 kilos					65.2

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

PRACTICAL HINTS ON JAM PROCESSING

What is the best Procedure to follow in using GENU Pectin

GENU Pectin is used in the jam manufacture either in powder form or converted into a solution.

The Use of Powdered GENU Pectin.

If GENU Pectin is to be added to the jam in powder form, mix it thoroughly with about ten times its weight of sugar. The amount of sugar to be added to the pectin must be taken from the quantity stated in the formula, in order that the total amount of sugar does not exceed the quantity stipulated. In the following is stated at what time the pectin must be added, depending on whether the fruit is fresh, or whether it has been preserved.

Caution:

Powdered GENU Pectin mixed with sugar must always be added to the batch before addition of the sugar bulk. The pectin cannot dissolve if the sugar has been added in whole or in part, and if the pectin does not dissolve it will not set.

The Use of GENU Pectin Solution.

When dissolving GENU Pectin in water, the dispersing of the pectin is facilitated when it is mixed with 5 times its weight of sugar. We recommend to make a pectin solution corresponding to 8 Grades, the composition being as follows:

> Mix carefully 1 kilo of GENU Pectin Type A or D 200 Grade with 5 kilos of sugar. Whip the pectin/sugar mix slowly into 19 kilos of boiling water and boil through.

We do not advise the preparation of pectin solutions a day in advance. Should it, however, for some reason or another be

wanted, the solution must immediately when ready be preserved with 1—3% sulphur dioxyde 6% solution, which is the only preservative we can recommend. There is a great risk in having pectin solutions standing without sulphur dioxyde preservation. The jellifying ability of the pectin deteriorates very fast, not only in the event of fermentation in the solution, but also through enzyme deterioration. Even the most extreme cleanliness is frequently not sufficient to prevent the ruining of a pectin solution which has not been preserved.

A GENU Pectin Solution is added to the batch after the bulk of the sugar has been added.

The Use of GENU Pectin is depending on whether the Fruit is Fresh or Preserved.

Fresh Fruit.

When making jam of fresh fruit boil it through as you do normally. The amount of pectin stated in the formula mixed with 10 times its weight of sugar is added and the whole mass given a quick boil. Then add the sugar in 3—4 portions while still boiling.

Frozen Unsugared Berries.

The process is the same as in the case of fresh fruit.

Frozen Sugared Berries.

If the quantity of sugar added to the frozen fruit does not exceed 20% the pectin may be added in powder form, as stated in the directions for fresh fruit. If more than 20% of sugar has been added, it is necessary to use a pectin solution. The amount of pectin stated in the formula is dissolved and added to the batch as stated above. In order to facilitate the processing we recommend to prepare the requirements of pectin solution for the day in the morning, and at any rate some hours

before use in order to secure a good solution. If boiling water is used, the pectin dissolves quicker.

Unsugared Pulp in hermetically sealed Tins.

The pectin is used in the same way as in case of fresh fruit.

Sugared Pulp in hermetically sealed Tins.

The pectin is used as in the case of sugared frozen fruit.

Pulp preserved with Sulphur Dioxyde or similar Preservatives.

If the pulp is preserved with sulphur dioxyde, it is necessary to cook it out of the pulp before the powdered GENU Pectin is added. If the pectin is added before the preservative has been cooked out, part of its jellifying power may be destroyed on account of the long cooking. Furthermore it must be considered that the pectin increases the viscosity, and consequently will prevent a complete removal of the preservative if added before.

Chemically preserved Sugared Pulp.

The pectin is used in the same way as in the case of sugared frozen fruit.

Addition of Sugar.

It is recommended to add the sugar in 3—4 portions, in order that the batch be kept constantly at boiling point, or at a temperature as near to boiling point as possible. If the batch is cooled considerably by addition of the cold sugar at once, there is a risk that the jam starts setting on account of the rapid cooling.

How to determine the End Point of the Cooking Operation.

For a preliminary check of the soluble solids content wanted in the jam a thermometer is used. Table 12 and 13 indicate the boiling point for jams with various soluble solids content.

TABLE 12

Boiling Points of Jams at 760 mm Mercury Pressure.

Refractometer Soluble Solids	Boiling Point in Centigrades	Boiling Point in Fahrenheit
60	103.95	219.1
61	104.17	219.5
62	104.40	219.9
63	104.62	220.3
64	104.87	220.6
65	105.10	221.2
66	105.35	221.6
67	105.61	222.1
68	105.94	222.7
69	106.29	223.3
70	106.62	223.9
71	107.00	224.6
72	107.39	225.3
73	107.80	226.0
74	108.23	226.8
75	108.72	227.7
76	109.20	228.6
77	109.76	229.6
78	110.38	230.7
79	111.04	231.9
80	111.80	233.3

CAUTION: We strongly recommend to check the thermometer as often as possible. The final checking of the soluble solids in the jam is made with the refractometer.

TABLE 13

Correction Table for Barometric Pressures other than 760 mm.

Barometric Pressure	Correction in Centigrades	Correction in Fahrenheit
800	+ 1.44	+ 2.6
790	+ 1.09	+ 2.0
780	+ 0.73	+ 1.3
770	+ 0.37	+ 0.7
760	0.00	0.0
750	— 0.37	— 0.7
740	— 0.76	— 1.4
730	— 1.12	— 2.0
720	— 1.51	— 2.7
710	— 1.89	— 3.4
700	— 2.29	— 4.1
680	— 3.10	— 5.6
660	— 3.90	— 7.0
640	— 4.7	— 8.5
620	— 5.6	— 10.1
600	— 6.5	— 11.7
550	— 8.8	— 15.8
500	—11.3	— 20.3
450	—14.0	— 25.2
400	—17.0	— 30.6
350	—20.4	— 36.8
300	—24.1	— 43.4
250	—30.4	— 54.7

CAUTION: We strongly recommend to check the thermometer as often as possible. The final checking of the soluble solids in the jam is made with the refractometer.

Addition of Preservative and Colouring.

Preservative and colouring are only added after the cooking operation.

Addition of Acid.

The correct time for adding the acid depends on the size of the containers. It is a golden rule to add the acid as late as possible. If it is not necessary to cool the jam add the acid to the batches before filling. If the jam is to be filled into large containers, e.g. 10—20 kilos, it is necessary to cool the jam before filling, and it is recommended to add the acid to the cooling pan immediately prior to the filling.

FORMULAS FOR JELLIES MADE OF FRUIT JUICE AND IMITATION JELLIES

When composing formulas for jellies, factories with laboratory at disposal are recommended in the first place to make a laboratory analysis—as stated for jams—of the breaking strength of the ready made jellies. The methods, detailed described for jams, are exactly the same for jellies. We have therefore made the formulas for jellies exactly in the same way as for jams, making them applicable for factories with as well as without laboratory.

The breaking strength of the jellies has been fixed at 600 mm water pressure, and this consistency is according to our experience adequate for jellies packed in 1 kilo jars or smaller containers.

As in the case of jams, the fruits are divided into groups, and we assume that

Apple-, Black Currant- and Quince-Juice

are containing so much pectin that a jelly can be cooked of these fruit juices without additional pectin.

According to our experience juices able to form a jelly with their own pectin must have a grade value of 1.5 Grade.

The basis for the fruit juices containing this amount of pectin is that they are derived from fruits not over-ripe, that they are not depectinised, and that fermentation of any kind has been avoided. However, generally fruit juices made of apples, black currants or quinces are liable to lose part of their jellifying ability after long storage, and we therefore recommend to check the pectin content on the gelometer from time to time in order to establish when additional pectin will be necessary.

I *Cowberry, Gooseberry, Red Currant, Grape, Blackberry.*

	Jelly Units	Total Jelly Units	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit Juice 50 kilos at abt. **0.7** Grade	35			10	5.0
GENU Pectin D 200 Grade 150—200 g	30	65	600	100	0.15
Sugar 60 kilos				100	60.00
50% Citric Acid Solution 200—300 ml ..				50	0.10
YIELD 100 kilos					65.2

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

II *Orange Sweet, Raspberry, Strawberry, Orange Bitter.*

	Jelly Units	Total Jelly Units	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit Juice 50 kilos at abt. **0.3** Grade	15			8	4.0
GENU Pectin D 200 Grade 250—300 g	50	65	600	100	0.25
Sugar 61 kilos				10	61.00
50% Citric Acid Solution 400—500 ml ..				50	0.20
YIELD 100 kilos					65.4

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

III *Bilberry, Cherry, all Kinds of depectinised Fruit Juices.*

	Jelly Units	Total Jelly Units	Gelometer mm W. Press.	Soluble Solids	
				Refracto-meter	Kilos
Fruit Juice 50 kilos at abt. **0** Grade	0			10	5.0
GENU Pectin D 200 Grade 325—350 g	65	65	600	100	0.3
Sugar 60 kilos				100	60.00
50% Citric Acid Solution 200—400 ml ..				50	0.15
YIELD 100 kilos					65.4

COOKING TEMPERATURE: cook to 105.1° C. or 5.1° C. above the boiling point of water at your factory, or to 65% soluble solids.

Artificially coloured and flavoured Pectin Jellies.

When water and essence are used instead of fruit juice Formula III may be applied provided 5 kilos of sugar more than stated are used.

PRACTICAL HINTS ON JELLY PROCESSING

How to use GENU Pectin?

The same rules apply as stated on pages 52—54 inclusive for the use of GENU Pectin in jam processing.

Addition of Sugar.

See jam processing page 54.

Determination of the End Point of the Cooking Operation.

See jam processing pages 54—56 inclusive. To this may be added that in jelly processing the correct end of point of the cooking operation is extremely important, in order to keep the same sugar content—once found to be most suitable—each time. In jam processing a jel texture is not always wanted, which is, however, the case in jelly processing. When jellies are filled into small containers, a pre-setting may easily take place if the sugar content is too high, resulting in a wrong consistency in the jars, and if the pre-setting is very advanced, in a jelly filled with air bubbles.

Addition of Acid.

See jam processing page 57. We may in this connection point out that as far as jellies are concerned, it is of great importance to add the acid as late as possible. In the case of big containers of 5 kilos or more we recommend to add the acid to each individual container before filling. Generally stirring is not necessary, as the acid disperses, when the container is filled.

When small containers of 1 kilo or less are used, this method cannot be applied, and in this case we advise to cook as small batches as possible and only to add the acid to the cooked jelly immediately prior to the filling, which must then take place quickly.

What Type of GENU Pectin to be used in Jelly Processing?

As it appears from the formulas only GENU Pectin Type D is stated for jelly processing. This type is slow set, and as emphasized above it is in this manufacture very important to prevent a pre-setting, in other words to cook the jelly in a way that no setting takes place, until the jelly has been filled into the small containers. This can only be attained by employing a slow set pectin. If a rapid set pectin is used, very small batches and very quick filling is essential.

QUESTIONS AND ANSWERS

Marmalade, Jam and Jelly Processing

As already mentioned in the preface the practical marmalade, jam and jelly processing has not been referred to in our formulas. *"Questions and Answers"* is an attempt to give some hints on this processing, but as most probably not all problems have been dealt with, we shall be glad to respond to inquiries, thouroughly, carefully and quickly.

1. What is GENU Pectin Type A and Type D?

Both types of pectin are carefully standardized so that users may safely rely on the grade value labelled on the packing being absolutely uniform from container to container and from consignment to consignment. Consequently a formula with GENU Pectin once fixed need not to be changed, provided the other raw materials are the same.

The difference between Type A and Type D is exclusiveiy due to the setting time. GENU Pectin Type A is Rapid Set, GENU Pectin Type D Slow Set. Re the employment of either type see pages 41 and 42.

2. In which Grade Values can GENU Pectin be obtained?

GENU Pectin is delivered standardized in 150 Grade, 160 Grade and 200 Grade.

3. Is the jellifying Power of GENU Pectin stated in International Grade?

No international grade standard exists, but we may state that a series of experiments made at our laboratory has proved the grade value claimed by various leading pectin factories to be exactly corresponding to the grade value claimed by us, in spite of the fact that these factories are using different testing methods. However, by employing a gelometer as described in this Handbook users themselves can test the jellifying ability of all commercial pectins.

4. What Boiling Point must a Batch of Jam have, when a certain Sugar Percentage is desired?

See pages 54 to 56 inclusive.

5. How is GENU Pectin dissolved, and when must it be added to the Batch?

Both questions are depending on, whether fresh fruit or pulp is used, and how the latter is preserved. See pages 52—54 inclusive.

6. What Time must Acid be added?

Generally the acid must be added as late as possible. If the jam is being filled from the cooking kettle directly into containers add the acid to the batch. If the jam is cooled in order to be filled into big containers add the acid to the cooling pan. Regarding this important point we refer to page 57 and page 60.

7. Is it always necessary to add Acid?

GENU Pectin Type A and Type D contain no acid, and as a certain amount of acid must be contained in the finished product in order to obtain a suitable consistency and flavour, acid must necessarily be added to all fresh fruit. Fruit pulps and preserved fruit juices may contain a certain amount of acid originating from the preservative, and even if part of it evaporates, some is always left, it may be so much that the finished batch shows the right p_H without addition of extra acid. If p_H is too high add acid, until the right p_H is reached.

If the batch shows the right p_H without addition of acid, add nevertheless a trifle. as in practise this has proved to give better results.

8. What is the Effect of Acid?

The effect is that the acid forces back the dissociation of the pectin with resultant jel formation. Acid may also be added to enhance the flavour.

9. May too big an Addition of Acid be dangerous?

Yes. The result will be too rapid a setting and a consequently long post-setting time which causes syneresis. In addition there is the risk of too big inversion, advancing the syneresis further.

10. Why use varying Amounts of Acid for different Fruits?

The amount of acid depends on the fruit content, its buffer capacity and the p_H. For example: the greater the buffer capacity of a fruit, the bigger the amount of acid to be added in order to change p_H with a given figure. Se Table 9, page 43.

11. Why use varying Amounts of different Acids to obtain the same Results?

The various acids have not the same ability of changing p_H in the given solution. Therefore interchangeable acid solutions have been stated in Table 9 page 43 (Standard Acid Solutions).

12. What is the Significance of the p_H Value in Relation to Jam Processing?

p_H is a numerical statement of the effective acidity of jam and is a deciding factor for the setting, as the p_H value has influence on the setting time, the syneresis and the inversion.

13. What p_H in the finished Product?

This depends on the soluble solids content. See Table 1, page 22.

14. How is the p_H Value in Fruit and Jam determined?

By means of a p_H Meter with glass electrode. The p_H values in jam stated in this Handbook are measured directly in the jam without water dilution. Therefore they are 0.1—0.2 units less than they would be, if dilution with one part of water had been made.

15. Is it necessary to increase the Amount of Pectin, in case of the Finished Product being filled into bigger Containers?

Yes, otherwise the finished product cannot stand transportation. As to the amount of pectin to be used in this case see Table 11, page 45.

16. Is it necessary to add Preservative to Jams?

If the sugar percentage is more than 68%: NO. If it is less than 68%, and the product is to be packed in jars or other containers not hermetically sealed: YES. Generally benzoate of soda is used.

If fresh fruit is used, we recommend to add benzoate of soda. In case of fruit pulp the addition may be diminished, as some of the preservative always remains, even if the pulp has been cooked vigorously, say 10 minutes. Dissolve the benzoate of soda in 5 times its weight of boiling water.

17. Is the Amount of Pectin to be used depending on the Soluble Solids in the Finished Product?

Yes, it is inversely proportional. Increasing the soluble solids, less pectin must be employed and reducing the soluble solids more pectin. See Table 7, page 39.

18. How is the Soluble Solids Content in Jams and Jellies determined?

Two methods are generally applied:

a) By means of Thermometer—see Question 19.

b) By means of Refractometer (Sugar Refractometer)—see Question 20.

19. How is the Total Soluble Solids Content determined by Thermometer?

When the batch is being evaporated, the cooking temperature rises as the soluble solids increases. Re the influence of the boiling point on the soluble solids see Table 12, page 55.

Remember to make correction for the boiling point stated, if your factory is placed above sea-level, see Table 13, page 56.

Remember to use a good thermometer and to adjust it frequently by determining the boiling point of water, at least once a week.

20. How is the Total Soluble Solids Content determined by Refractometer?

A refractometer is indispensable in every up-to-date jam factory. By means of the refractometer the soluble solids may be exactly determined in a few seconds from only one or two drops of the batch. If a sugar refractometer is used, it reads directly in %-Refractometer Soluble Solids. Other refractometers give index of refraction (Table 18, page 94 gives correlation to the % Soluble Solids).

21. How is the Amount of Acid fixed to be added to a Batch of Jam?

The various fruits have highly varying amounts of acid. Table 9, page 43 is indicating the approx. p_H of the various fruits, and furthermore the approx. amount of acid to be used. However, this information may only serve as a guide, and it is of the greatest importance to check the exact p_H, when the batch is finished.

Has a formula once proved to give satisfactory results with a certain fruit, occasional control tests of p_H should be sufficient.

22. The Jam or the Jelly has not the Firmness wanted. What is the Reason?

We take it for granted that the amount of pectin has been correctly calculated according to the instructions in this Handbook. If this is the case, the poor result must be due to:

1) That setting has started before the filling (premature setting), caused by

   a) too much acid—check p_H in the jam.

   b) too acid pulp—check p_H in the pulp and increase p_H to 2.9—3.0 by adding trisodium phosphate or sodium hydroxyd.

   c) too heavy a cooling before filling.

2) a) Part destruction of the pectin as a result of too long a cooking time, due to the fact that the formula has been composed in a way that a great amount of water must be evaporated.—Revise the formula so that the cooking time is reduced to a few minutes. If it is desired to concentrate the fruit or the pulp in order to obtain a bigger fruit content concentrate preferably in vacuum boiler before adding the pectin.

   b) Destruction of the pectin as a result of too slight a cooling of the batch before filling into large containers.—It is easily checked, as in that case the verge of the jam in the container will be firm whereas the centre will be weak.

3) Cooking fault so that the refractometer soluble solids in the finished product is less than stipulated in the formula.—Adjust thermometer or refractometer.

4) The p_H in the jam is not correct.—Adjust the addition of acid.

23. The Finished Product shows considerable Syneresis. What is the Reason?

The syneresis may be due to:

a) too low p_H in the finished product. For correct p_H values see Table 1, page 22. Re syneresis see pages 27 and 28.

b) too great a contents of invert sugar caused by too low a p_H in the pulp or too long cooking at high temperature. Re invert sugar see pages 27 and 28.

c) too rapid a setting, which may be due to too low p_H in the finished product.
d) too little an amount of pectin.
e) too little an amount of sugar.

24. The Finished Product chrystallizes. What is the Reason?

Generally that too little amounts of invert sugar have been created during the cooking operation. In that case we recommend to add some acid in the beginning of the operation. This will increase the inversion. The correct percentage of invert-sugar is stated in Table 2, page 27.

25. How is a defective Batch worked up?

The defective jam must be included successively in the following batches. If the error in the cooking is not due to wrong addition of pectin, but due to wrong addition of acid, wrong soluble solids etc. the further treatment of the jam takes place as follows:

In order to melt the jam and restore the jellifying ability of the added pectin as well as that of the pectin in the fruit, heat the defective jam to boiling point in such a dilution that you have maximum 30% of sugar in the defective jam. This may be done according to this formula:

> Put 45 kilos of fresh fruit or fruit pulp in the cooking kettle. Mix the amount of pectin calculated for this quantity with 5—6 times its weight of sugar. Add the pectin-sugar mixture to the batch as it is being stirred with a paddle. Heat to boiling and boil for 1 minute. Add 25 kilos of defective jam (soluble solids 65%) in disintegrated form. Boil the batch for 1—2 minutes and add sugar, until the soluble solids content shows the percentage wanted. Finish the cooking operation as usually.

CAUTION: If the defective batch is due to too little addition of pectin, the deficient amount must be additionally added together with the pectin amount calculated for the pulp.

26. If you have Questions, which we have not dealt with,

please write us directly to our address in Copenhagen or through our exclusive representative in your country. We are fully at your service, also with the examination of raw materials and defective jam. In the latter case please submit together with the sample of the defective jam also a 1-kilo sample of the pulp used, or in case of fresh fruit same properly preserved.

METHOD FOR DETERMINATION OF PECTIN GRADE

by

MODIFIED TARR-BAKER GELOMETER

developed by

KØBENHAVNS PEKTINFABRIK

INTRODUCTION

In the various countries where pectin is subjected to scientific control, a number of testing methods exist differing more or less, and the scientific basis of which is highly open to discussion. Common to most of these methods is that even if they may be applied, that is give reproducible and reliable measures for the product of the pectin factory in question, they partly fail when they are used to test the products of other factories.

When preparing this analysis method, we therefore subjected it to the following conditions:

1) It must give reproducible results.
2) It must be quick.
3) It must be so simple that laboratory assistents can make it quickly.
4) It must be as similar to practise as in any way possible without the accuracy being slackened.
5) The property of the pectin jelly expressing the grade value of the pectin must be the property having the greatest importance to the jam industry.
6) The grade value found must preferably have relation to a physical-chemical property of the pectin, for example simply depend on the molecular weight.
7) The method applied to products of other pectin factories must as far as possible give grade values corresponding to those stated by these factories, as it will only confuse the pectin consumers to operate with different grade values of a given pectin.

Re 1) *The Method for Determination of Pectin Grade by Modified Tarr-Baker Gelometer developed by* KØBENHAVNS PEKTINFABRIK gives with employment of experienced staff fully reproducible results. This has been tried out and proved not only in Denmark but also in a number of other countries.

Re 2) It is very quick, a test taking maximum 4 hours contrary to that of most other usable methods taking about 24 hours.

Re 3) It is very simple, enabling the laboratory assistant to use it skilfully and satisfactorily in about 6—7 days.

Re 4) This condition has been fulfilled in the way that the cooking operation, the sugar concentration in the finished jelly and the p_H has been fixed on values corresponding to those in practise. At the same time we have, when preparing and fixing the composition of the synthetic buffer solution, made it a strict condition that the strength of jellies cooked with buffer solution must correspond exactly to that of jellies cooked with natural depectinized strawberry- or raspberry-juice and acid (as in practise), and this has been attained.

Re 5) In determining the grade value of the pectin by measuring the breaking strength of the jelly, we believe having accounted for the jel property, which is in our opinion of the greatest importance to a jam manufacturer, as this property is deciding the resistance of the products to destruction during transportation etc.

Re 6) It has been experimentally proved that the grade value determined by this testing method is simply functionary depending on the molecular weight of the pectin in question, this weight being viscosimetrically determined in aqueous solution. This is of a certain importance, as it is dangerous to any analysis method to have no simple scientific relation to any physical-chemical property.

Re 7) This stipulation has been fulfilled as far as possible, as we are using the practically internationally recognised American definition of pectin grades:

> 1 kilo of pectin 100 Grade must be able to form a standard jelly with 100 kilos of sugar, when the finished jelly has a soluble solids content of 65% and a p_H of 3.0.

To avoid to introduce a grade value of pectin, differing from that of other leading pectin factories (their standard jellies and testing methods being not the same as

ours) we have when fixing the standard jelly cooked jellies with pectins from these factories and measured them according to our testing method. On the basis of the strength properties of the these jellies, the standard jelly has been fixed in a way that as many as possible of these other pectins are showing the grade value stated. The result consequently achieved is that the grade value stated for our GENU Pectin is comparable with that stated for the pectins of other factories.

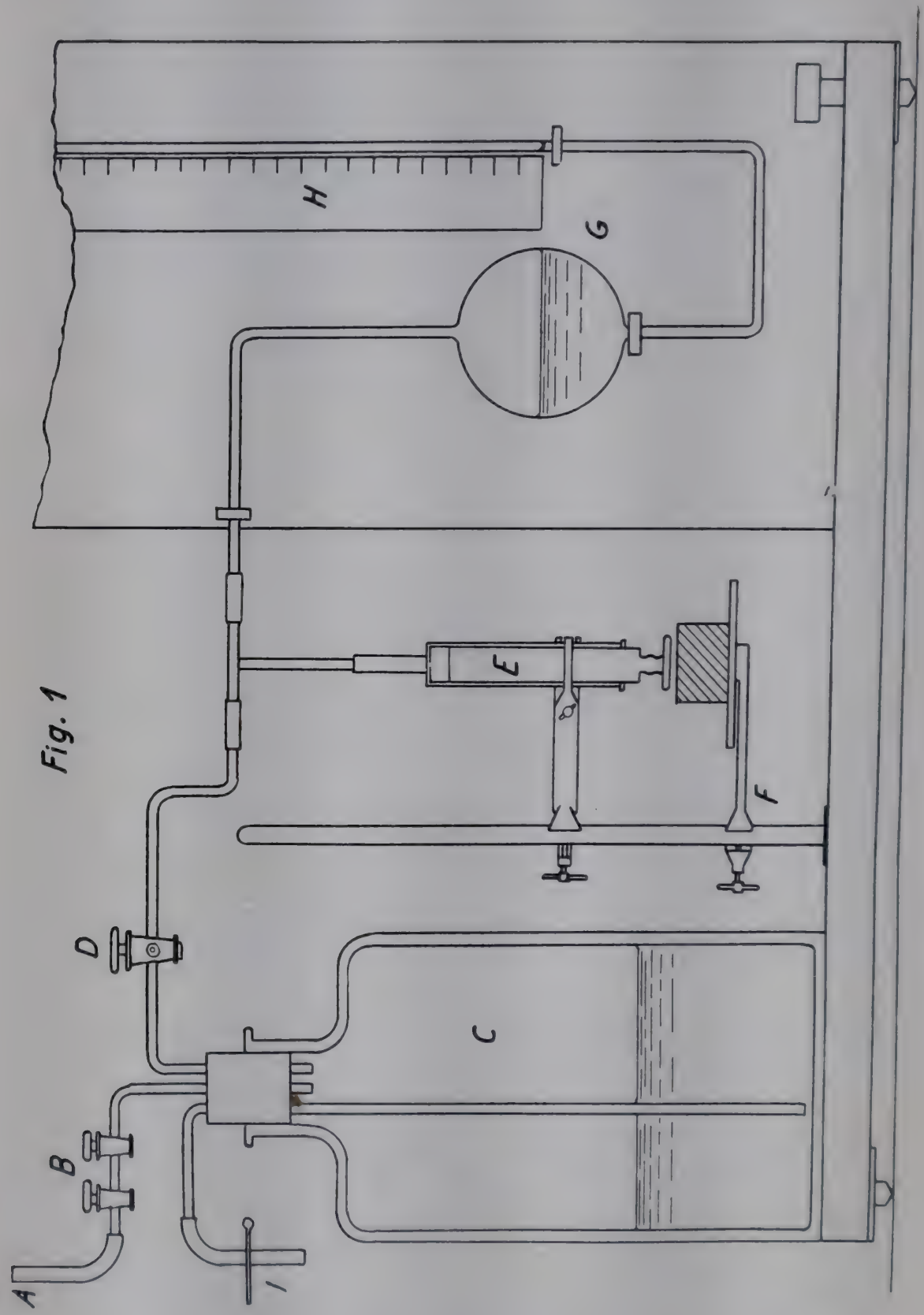


Fig. 1

LABORATORY INSTRUCTIONS

The following laboratory instructions are giving detailed directions for the application of this testing method for Pectin. The instructions are so detailed and instructive, in order to enable laboratory assistants to carry out tests. At the same time examples will show the use of the nomograms.

1. The Gelometer.

The apparatus (Gelometer) used in measuring the breaking strength of a jelly is first described by Tarr-Baker.

As in 1944 it was obviously quite impossible for us to get information of the exact dimensions of the Tarr-Baker apparatus, we constructed one based upon the same principles. The principle of the apparatus is shown in figure 1, page 74 and photo reproduction page 70. It consists of

A) 25-liter levelling bottle
B) 2 stop cocks
C) 2-liter bottle
D) 3-way stop cock
E) Piston
F) Revolving table
G) Manometer
H) Graduated scale
I) Drain.

and operates as follows:

The air-pressure is created, when the water passes from A to C. The stream of water is best regulated by means of a capillary tube placed before B (not shown in figure 1 page 74). The pressure is measured by means of the manometer G. Through the application of the 3-way stop cock D the system can be brought into communication with the atmosphere. The piston E is a 10 ml Lüer squirt, where the piston is plain cut with round edge.

Dimension of Piston:	The proportion between the area of the piston and that of the pressure plate must be 0:485.
Diameter of Pressure Plate:	Approx. 2.1 cm.
Weight of Piston:	12 g.

It must always be well lubricated with paraffin-oil and on no account be allowed to adhere. This may occur, if some of the jelly has got stuck to the piston. Should this happen, it will be necessary to remove and clean the piston thoroughly, after which it must be well lubricated with the paraffin-oil. The manometer G consists of a 1300 mm glass-tube and a 100 ml reservoir. It is half filled with coloured water. The difference in level in the reservoir at minimum and maximum pressure is so small that the graduated scale H can be fixed with constant zero-point at the middle of the reservoir. The jelly sample is placed on table F. By means of the drain with cock I the level in C can be regulated.

The gelometer is adjusted as follows:

Place a firm body under the piston. Open the three-way tap to equalize any variation of pressure and close again. Then open the closure tap B, and the pressure begins to rise. Now measure the time it takes the fluid to rise to the 300 mm mark. If it takes more than 60 seconds, raise the stand of the fluid in bottle C, measure again and so on, until the pressure rises at 300 mm in 60 seconds. The gelometer is now adjusted, and may be used for determining the strengths. Generally it is not necessary to adjust more than once a day.

2. The Jelly Rings.

(See photo page 24.)

These have an inside diameter of 35 mm, height 27 mm. It is essential that the rings are quite plane, otherwise they will not fit closely to the surface of the glass plate. Similarly it is an advantage that the rings are as heavy as possible, in order to stand firm on the glass plate. Rings made of glass easily tip up, while the jelly is being moulded. We therefore recommend copper rings, which have the additional advantage

that they do not break. The rings must be greased along the whole of the edge with a thin layer of vaseline, so that they fit tightly to the glass plate. The inner surface must be thoroughly oiled with paraffin oil in order to facilitate the withdrawing of the ring, and we further recommend to put a drop of paraffin oil into the bottom of the rings or to lubricate the glass plate with silicon grease, as various pectins have a definite tendency to stick to glass so that the glass plate can only be removed with difficulty without spoiling the surface of the jelly, when the strength is to be determined. The jelly rings must *always be filled and then kept absolutely still for three hours in a place with a temperature of 20° C. ± 2° C., until the determination takes place.* The jellies must be placed on a shelf, where they are not exposed to vibrations of any kind. Short vibrations or knocks render a special danger and must be avoided, as a jelly having been subjected to such vibrations whilst jellifying does not show the maximum strength.

3. Jelly Cooking.

This is the most important operation, and at the same time it is exposed to most dangers. It is of course essential that the person doing this work has some experience, as with this work, like with all analysis methods, one is apt to commit slight errors in the beginning. However, this method is so simple that it can be carried out in a fully satisfactory way fairly soon. The following is a description of the cooking operation with examples as detailed as possible, including our many years experiences at the Laboratory of KØBENHAVNS PEKTIN-FABRIK.

a) Powdered Pectin determined at 65% Soluble Solids.

We assume that a determination of a powdered pectin claimed to be 250 Grade is to be made.

First of all the amount of pectin to be used in cooking the jelly must be found by means of nomogram fig. 2 as follows:

As a breaking strength of approx. 500 mm W.P. is suitable (the most suitable water pressure is between 300 and 600 mm) draw a line through the point "500 mm W.P." and the point

"250 Grade". The line intersects the scale "g Pectin" at the point ~ 0.5 g. It is therefore decided to cook the jelly with 0.5 g pectin. Then weigh off 123.0 — 0.5 = 122.5 g of sugar into a beaker and take the tare of a 400 ml beaker (with spatula). Weigh on a watch glass 0.500 g of pectin, employing an analytical balance. Transfer the pectin carefully with a camel hair brush to the tared beaker. Pour approx. 10 g of the sugar apportioned into the pectin and mix carefully with spatula. Add from a measuring glass 34 ml. KP. buffer (see page 81) and 45 ml distilled water, while carefully stirring. Heat the mixture just to boiling point, at which the pectin generally will dissolve. If the pectin does not contain lumps, and the sugar and pectin are mixed carefully, there is no difficulty in dissolving the pectin. It may sometimes be necessary to keep the solution just at boiling point for 2—3 minutes before the pectin dissolves, and generally this does not matter. However, if any pectin lumps at all are floating in the solution after 3 minutes, the determination must be repeated. As usually very small quantities of pectin are to be used, great care must be taken with the stirring in order that no pectin shall stick to the side of the glass above the fluid, as then it will hardly dissolve. When the pectin has dissolved add 40—50 g of the sugar previously weighed and stir vigorously. Heat quickly the contents of the beaker to a beginning boil. Add further 40 g of the sugar and continue the heating while stirring vigorously, but with caution. When the liquid is again at boiling point, add the remaining 40 g of sugar and boil for 10 seconds. Then place the beaker on the balance. The content will generally weigh approx. 200 g and must be brough to the exact weight of 200 g by either adding a few drops of distilled water or by stirring vigorously with spatula, until any surplus water has evaporated. Should the content weigh more than 201 g, resume the boiling over the Bunsen burner, as the evaporation of 1 g of water without boiling will take too long. Conversely in case that not more than 4—5 g of distilled water has to be added to bring up the weight to 200 g, it is not necessary to heat to boiling point. When the content weigh exactly 200 g pour into 5 jelly rings. The rings must be filled up and allowed to stand completely still for 3

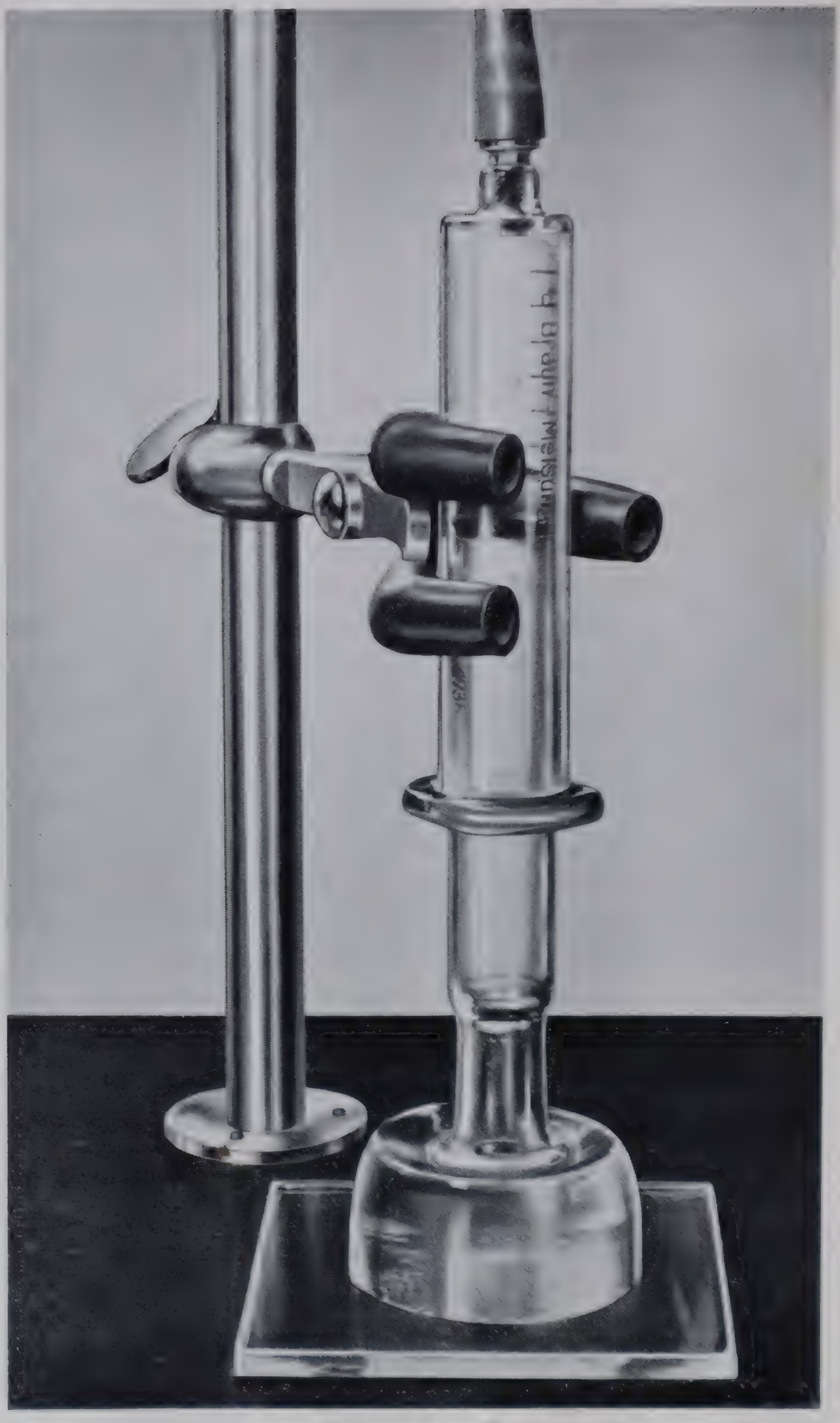
hours at 20° C. ± 2° C. after which the strength is measured as described in the following.

Place the jelly rings in front of the gelometer. Put glass plates over the filled rings and turn them over. Lift the original bottom plate by loosening the glass plate from the ring on one side. The jelly will then generally slip off the plate, which is removed. Now remove the ring by lifting it slowly. The jelly will smoothly slip out of the ring, which must of course not be removed so rapidly that the jelly is lifted from the glass plate. Place the jelly on table F and the piston on the jelly surface. Open the three-way tap to equalize differences in pressure and close again. Open closure tap B, and the pressure begins to rise. The manometer fluid now rises slowly until the jelly is broken by the piston. Note the manometer reading at this point and remove the jelly. By drain S regulate the fluid level in C to starting point, i. e. until the manometer shows the pressure 0. Test the remaining jellies in the same way.

Suppose the breaking strengths are 550, 510, 515, 545 and 530, with an average of 530. In the event of the piston having stuck during any of the tests, the breaking point reading must of course be omitted. The same is the case if one of the jelly surfaces has been spoilt, or if the jelly has been split when measured. The breaking strength of the jelly in question was 530 mm W.P., and the pectin grade may be found by means of nomogram fig 2. Draw a line through the point "530 mm W.P." and the point "0.5 g Pectin". The line intersects the scale "Grade" at point 252. The grade value of the pectin used was therefore 252 Grade. Now only the soluble solids and the p_H of the jelly has to be controlled, which must be 65.0% ± 0.5% respectively 3.00 ± 0.05.

b) Liquid Pectin determined at 65% Soluble Solids Content.

Let it be assumed that a determination of a liquid pectin claimed to be 8 Grade is to be made. Find the soluble solids content of the pectin by the refractometer. Suppose it is 15.6%. Then find the p_H by means of the p_H Meter. This is for instance 3.08. Reduce the p_H value to 2.7—2.8 by adding concentrated



hydrochlorid acid (2—3 drops per 100 g of pectin). Now find the amount of pectin to be used in cooking the jelly by means of the nomogram fig. 3 as follows:

As a breaking strength of approximately 400 mm water pressure is suitable (the most suitable water pressure is between 300—600 mm), draw a line through the point "400 mm W.P." and the point "8 Grade". The line intersects scale "g Pectin" at the point 14.0. It is therefore decided to cook the jelly with 14 g of pectin. Then determine the amount of granulated sugar to be used by nomogram fig. 1, by drawing a straight line through the point "14 g Pectin" and the point "15.6% Soluble Solids". This line intersects the scale "g Sugar" at the point 122.7. The jelly must therefore be cooked with 122.7 g of sugar. Weigh 122.7 g of sugar in a beaker and take the tare of a 400 ml beaker (with spatula). Now weigh 14 g of the liquid pectin. The weight must be exact to 0.02 g. Add with a 25 ml pipette or a measuring glass 25 ml KP. buffer (see below) and then 40 ml of distilled water. Place the beaker upon a tripod with asbestos wire netting and lit the Bunsen burner. Add 40—50 g of the sugar previously weighed and stir vigorously. Heat quickly the contents of the beaker to a beginning boil and continue the determination as described under a).

After three hours an average breaking strength of for instance 403 mm W.P. is found corresponding to a pectin value of 8.0 Grade according to nomogram fig 3.

Caution

Certain powdered pectins are so low in acid that with the KP. buffer the p_H in the jelly cannot be reduced to 3.00 $\pm$ 0.05. In such cases we recommend to add 0.4—0.5 ml of lactic acid during the boiling.

KP. Buffer Solution.

1) 16 g Calcium Citrate $Ca_3(C_6H_5O_7)_2,4H_2O$.
2) 152 g Citric Acid $C_6H_8O_7,H_2O$.
3) ~~122~~ g Sugar. 220
4) 38.4 g Potassium Citrate $K_3C_6H_5O_7,H_2O$.

How to make XP Buffer Solution

Boil 1) and 2) in 1 liter of distilled water until dissolved. Add 3) and 4) and cool. After cooling fill into a 2 liter volumetric flask and fill up to the mark with distilled water.

Characteristics:

Refractometer Soluble Solids: 18%.

p_H: 2.90 ± 0.05.

Nomogram
fig. 1

30

Fig. 2

Nomogram
fig. 2

Fig. 3

Nomogram
fig. 3

TABLE 14.

ABBREVIATIONS

ton metric	t.	liter	l.	gallon	gal.
kilogram	kg.	milliliter	ml.	quart	qt.
gram	g.	long ton	tn. l.	pint	pt.
milligram	mg.	short ton	tn. sh.	gill	gi.
cubic-meter	m^3	pound	lb. av.	ounce fluid	oz. fl.
cubic-decimeter	dm^3	ounce avoir du pois...	oz. av.	dram fluid	dr. fl.
cubic-centimeter	cm^3	dram	dr. av.	drachm fluid	dr. fl.

METRIC SYSTEM

1 t.	= 1000 kg.	= 1000 × 1000 g.		=	0.984206 tn. l. (Br.) 0.984206 tn. l. (U.S.)
1 kg.	= 1000 g.	= 1000 × 1000 mg.		=	35.273957 oz. av. (Br.) 35.273957 oz. av. (U.S.)
1 g.	= 1000 mg.	= 1000 × 1000 microgram		=	0.564383 dr. av. (Br.) 0.564383 dr. av. (U.S.)
1 m^3	= 1000 dm^3	= 1000 × 1000 cm^3 =	999.97 l.	=	219.97 gal. (Br.) 264.171 gal. (U.S.)
1 cm^3 =			0.99997 ml.	=	0.28157 dr. fl. (Br.) 0.27051 dr. fl. (U.S.)
1 l.	= 1000 ml.	= 1.000027 dm^3		=	1.7598 pt. (Br.) 2.1134 pt. (U.S)

TABLE 15.

U. S. SYSTEM

1 tn. l.	= 2240 lbs. av.	= 35840 oz. av.	= 1.016047 t.					
1 tn. sh.	= 2000 lbs. av.	= 29167 oz. av.	= 0.907185 t.					
1 lb. av.	= 16 oz. av.	= 256 dr. av.	= 453.5924 g.					
1 oz. av.	= 16 dr. av.	=	28.349527 g.					
1 dr. av.	=		1.771845 g.					
1 gal.	= 4 qt.	= 8 pt.	= 32 gi.	= 128 oz. fl.	= 3.7853 l.	= 3785.4 cm³		
1 pt.	= 4 gi.	= 16 oz. fl.	= 128 dr. fl.	=	473.167 ml.	= 473.179 cm³		
1 oz. fl.	= 8 dr. fl.	=			29.5729 ml.	= 29.5737 cm³		

BRITISH SYSTEM

1 tn. l.	= 2240 lbs.	= 35840 oz. av.	= 1.016047 t.					
1 lb. av.	= 16 oz. av.	= 256 dr. av.	= 453.5924 g.					
1 oz. av.	= 16 dr. av.		28.349527 g.					
1 dr. av.	=		1.771845 g.					
1 gal.	= 4 qt.	= 8 pt.	= 32 gi.	= 160 oz fl.	= 4.54596 l.	= 4546.1 cm³		
1 pt.	= 4 gi.	= 20 oz. fl.	= 160 dr. fl.	=	568.25 ml.	= 568.26 cm³		
1 oz. fl.	= 8 dr. fl.	=			28.4122 ml.	= 28.4130 cm³		

TABLE 16.

TEMPERATURES — CENTIGRADE TO FAHRENHEIT

Conversion Table
for temperatures above 0° C.

Temp.°C.	0	1	2	3	4	5	6	7	8	9
0	32.0	33.8	35.6	37.4	39.2	41.0	42.8	44.6	46.4	48.2
10	50.0	51.8	53.6	55.4	57.2	59.0	60.8	62.6	64.4	66.2
20	68.0	69.8	71.6	73.4	75.2	77.0	78.8	80.6	82.4	84.2
30	86.0	87.8	89.6	91.4	93.2	95.0	96.8	98.6	100.4	102.2
40	104.0	105.8	107.6	109.4	111.2	113.0	114.8	116.6	118.4	120.2
50	122.0	123.8	125.6	127.4	129.2	131.0	132.8	134.6	136.4	138.2
60	140.0	141.8	143.6	145.4	147.2	149.0	150.8	152.6	154.4	156.2
70	158.0	159.8	161.6	163.4	165.2	167.0	168.8	170.6	172.4	174.2
80	176.0	177.0	179.6	181.4	183.2	185.0	186.8	188.6	190.4	192.2
90	194.0	195.8	197.6	199.4	201.2	203.0	204.8	206.6	208.4	210.2
100	212.0	213.8	215.6	217.4	219.2	221.0	222.8	224.6	226.4	228.2
110	230.0	231.8	233.6	235.4	237.2	239.0	240.8	242.6	244.4	246.2
120	248.0	249.8	251.6	253.4	255.2	257.0	258.8	260.6	262.4	264.2
130	266.0	267.8	269.6	271.4	273.2	275.0	276.8	278.6	280.4	282.2
140	284.0	285.8	287.6	289.4	291.2	293.0	294.8	296.6	298.4	300.2
150	302.0	303.8	305.6	307.4	309.2	311.0	312.8	314.6	316.4	318.2
160	320.0	321.8	323.6	325.4	327.2	329.0	330.8	332.6	334.4	336.2
170	338.0	339.8	341.6	343.4	345.2	347.0	348.8	350.6	352.4	354.2
180	356.0	357.8	359.6	361.4	363.2	365.0	366.8	368.6	370.4	372.2
190	374.0	375.8	377.6	379.4	381.2	383.0	384.8	386.6	388.4	390.2

TABLE 17

Relation between Per Cent of Sucrose (Degrees Brix), Degrees Baume, Specific Gravity at 20° C., Grams Sucrose in 1 Liter of Syrup at 20° C. and Grams Water in 1 Liter of Syrup at 20° C.

Per Cent Sucrose (Degrees Brix)	Degrees Baume	Specific Gravity at 20° C.	Grams Sugar in 1 Liter of Syrup at 20° C.	Grams Water in 1 Liter of Syrup at 20° C.
0	0.00	1.00000	0.000	1000.00
1	0.56	1.00039	10.004	990.39
2	1.12	1.00780	20.056	987.74
3	1.68	1.01173	30.352	981.38
4	2.24	1.01569	40.628	875.06
5	2.79	1.01968	50.984	968.70
6	3.35	1.02369	61.421	962.27
7	3.91	1.02773	71.941	955.79
8	4.46	1.03180	82.544	949.26
9	5.02	1.03590	93.231	942.67
10	5.57	1.04003	104.00	936.03
11	6.13	1.04418	114.86	929.32
12	6.68	1.04837	125.80	922.57
13	7.24	1.05259	136.84	915.75
14	7.79	1.05683	147.96	908.87
15	8.34	1.06111	159.17	901.94
16	8.89	1.06542	170.47	894.95
17	9.45	1.06976	182.04	887.72
18	10.00	1.07413	193.34	880.79
19	10.55	1.07853	204.92	873.61
20	11.10	1.08297	216.59	866.38
21	11.65	1.08744	228.36	859.08
22	12.20	1.09194	240.23	851.71
23	12.74	1.09647	252.19	844.28
24	13.29	1.10104	264.25	836.79
25	13.84	1.10564	276.41	829.23
26	14.39	1.11027	288.67	821.60
27	14.93	1.11493	301.03	813.90
28	15.48	1.11963	313.50	806.13
29	16.02	1.12436	326.06	798.30
30	16.57	1.12913	338.74	790.39
31	17.11	1.13394	351.52	782.42
32	17.65	1.13877	364.41	774.36
33	18.19	1.14364	377.40	766.24
34	18.73	1.14855	390.05	758.50
35	19.29	1.15350	403.73	749.78
36	19.81	1.15847	417.05	741.42
37	20.35	1.16349	430.49	733.00
38	20.89	1.16853	444.04	724.49
39	21.43	1.17362	457.71	715.91
40	21.93	1.17874	471.50	707.24
41	22.50	1.18390	485.40	698.50
42	23.04	1.18910	499.42	689.68
43	23.57	1.19434	513.57	680.77
44	24.10	1.19961	527.83	671.78
45	24.63	1.20491	542.21	662.70

TABLE 17 *(Continued)*

Per Cent Sucrose (Degrees Brix)	Degrees Baume	Specific Gravity at 20° C.	Grams Sugar in 1 Liter of Syrup at 20° C.	Grams Water in 1 Liter of Syrup at 20° C.
46	25.17	1.21026	556.72	653.54
47	25.70	1.21564	571.35	644.29
48	26.23	1.22106	586.11	635.95
49	26.75	1.22656	601.01	625.55
50	27.28	1.23202	616.01	616.01
51	27.81	1.23756	631.16	606.40
52	28.33	1.24313	646.38	596.75
53	28.86	1.24874	661.83	586.91
54	29.38	1.25439	677.37	577.02
55	29.90	1.26007	693.04	567.03
56	30.42	1.26580	708.85	556.95
57	30.94	1.27156	724.79	546.77
58	31.46	1.27736	740.87	536.49
59	31.97	1.28320	757.09	526.11
60	32.49	1.28908	773.45	515.63
61	33.00	1.29498	789.94	505.04
62	33.51	1.30093	806.58	494.35
63	34.02	1.30694	823.37	483.57
64	34.53	1.31297	840.27	472.70
65	35.04	1.31905	857.38	461.67
66	35.55	1.32516	874.61	450.55
67	36.05	1.33129	891.96	439.33
68	36.55	1.33748	909.49	427.99
69	37.06	1.34371	927.10	416.55
70	37.56	1.34997	944.98	404.99
71	38.06	1.35627	962.95	393.32
72	38.55	1.36261	981.08	381.53
73	39.05	1.36900	999.37	369.63
74	39.54	1.37541	1017.80	357.61
75	40.03	1.38187	1036.40	345.47
76	40.53	1.38835	1055.15	333.20
77	41.01	1.39489	1074.07	320.83
78	41.50	1.40146	1093.14	308.32
79	41.99	1.40806	1112.37	295.69
80	42.47	1.41471	1131.77	282.94
81	42.95	1.42138	1151.32	270.06
82	43.43	1.42810	1171.04	257.06
83	43.91	1.43486	1190.93	243.93
84	44.38	1.44165	1210.99	230.66
85	44.86	1.44848	1231.21	217.27
86	45.33	1.45535	1251.60	203.75
87	45.80	1.46225	1272.16	190.09
88	46.27	1.46919	1292.89	176.30
89	46.73	1.47616	1313.78	162.38
90	47.20	1.48317	1334.75	148.32
91	47.66	1.49022	1356.10	134.12
92	48.12	1.49720	1377.52	119.78
93	48.58	1.50442	1399.11	105.31
94	49.03	1.51157	1420.88	90.694
95	49.49	1.51876	1442.82	75.938

TABLE 18

Refractive Index of Sucrose Solutions at 20° C.

Per Cent Sucrose	Refractive Index at 20° C.	Per Cent Sucrose	Refractive Index at 20° C.
0.0	1.3330		
1.0	1.3344	46.0	1.4117
2.0	1.3359	47.0	1.4137
3.0	1.3374	48.0	1.4158
4.0	1.3388	49.0	1.4179
5.0	1.3403	50.0	1.4200
6.0	1.3418	51.0	1.4221
7.0	1.3433	52.0	1.4242
8.0	1.3448	53.0	1.4264
9.0	1.3464	54.0	1.4285
10.0	1.3479	55.0	1.4307
11.0	1.3494	56.0	1.4329
12.0	1.3510	57.0	1.4351
13.0	1.3526	58.0	1.4373
14.0	1.3541	59.0	1.4396
15.0	1.3557	60.0	1.4418
16.0	1.3573	61.0	1.4441
17.0	1.3590	62.0	1.4464
18.0	1.3606	63.0	1.4486
19.0	1.3622	64.0	1.4509
20.0	1.3639	65.0	1.4532
21.0	1.3655	66.0	1.4555
22.0	1.3672	67.0	1.4579
23.0	1.3689	68.0	1.4603
24.0	1.3706	69.0	1.4627
25.0	1.3723	70.0	1.4651
26.0	1.3740	71.0	1.4676
27.0	1.3758	72.0	1.4700
28.0	1.3775	73.0	1.4725
29.0	1.3793	74.0	1.4749
30.0	1.3811	75.0	1.4774
31.0	1.3829	76.0	1.4799
32.0	1.3847	77.0	1.4825
33.0	1.3865	78.0	1.4850
34.0	1.3893	79.0	1.4876
35.0	1.3902	80.0	1.4901
36.0	1.3920	81.0	1.4927
37.0	1.3939	82.0	1.4954
38.0	1.3958	83.0	1.4980
39.0	1.3978	84.0	1.5007
40.0	1.3997	85.0	1.5033
41.0	1.4016		
42.0	1.4036		
43.0	1.4056		
44.0	1.4076		
45.0	1.4096		

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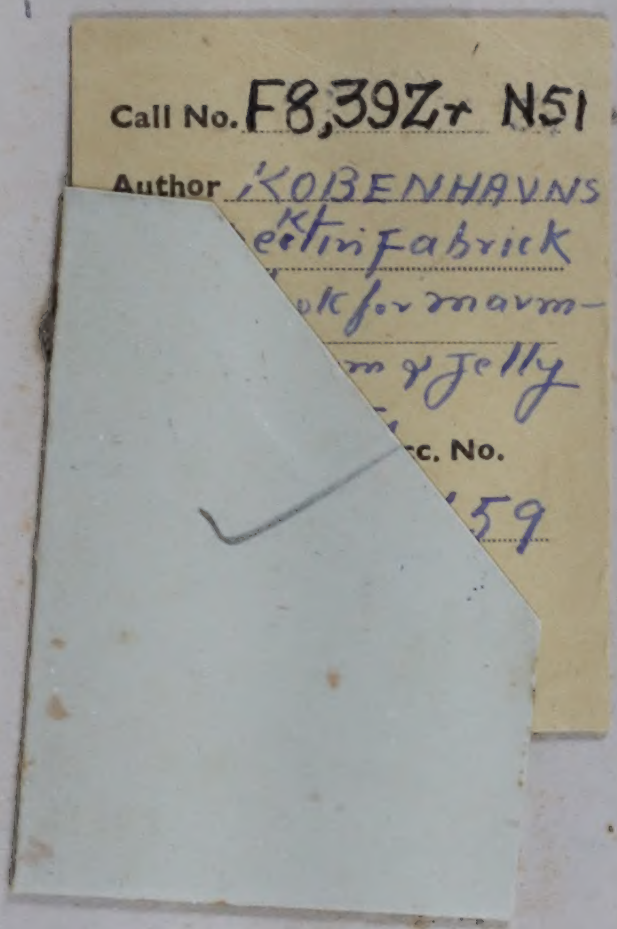
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